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THE USE OF ARTIFICIAL MANURES.

BY

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The use of artificial manures in tea cultivation is now very general, but in many quarters a great deal of prejudice against them is still met. On some gardens, for example, no manures other than those of organic origin, like cattle manure, oilcake and animal meal, are allowed to be used. Even in some places where "chemical" measures are being used with obvious advantage, the opinion is sometimes expressed that the good cannot last. The idea appears to be that there is something unnatural about a concentrated soluble manure. The great effect produced by the small quantity suggests that the manure acts like a tonic rather than a food; it is felt that there must occur eventually an unfavourable reaction, when the plants will suffer from the effects of their unnatural feeding.

Plants, however, can only take the nitrogen, potash and phosphoric acid which is necessary to them, from a complicated mixture, like, for example, cattle manure, when this has broken down in the soil into simple soluble substances, such as occur ready formed in soluble artificials.

The deterioration of a soil, when cropped without manures is due almost entirely to depletion in these three substances, and it has been shown by long-continued field experiment in many places that a crop's requirement of these essential foods can be as well supplied by soluble artificials as by cattle manure.

In the January number of the Journal of the Ministry of Agriculture, H. V. Garner of Rothamsted Experimental Station,

collects together the results of experiments on this question. His conclusion is—

"There is no doubt that the successful use of fer-
"tilizers without dung requires a knowledge of their properties
"and their relations to soils and crops, but that they can maintain
"fertility for a considerable time, and compare not unfavourably
"with repeated dressings of dung has been shown in a number
"of trials. In most of the recorded cases yearly applications of
"farmyard manure have been compared with annual doses of a
"complete mixture of fertilizers, the dung providing more total
"plant food than the artificial but, probably, rather less plant
"nutrients in a readily available form.

"The general trend of the results is in the same direction;
"and there is no doubt that under the conditions of the experi-
"ments artificials used alone have maintained the cropping
"power of the various soils at a level not much inferior to that
"produced by annual application of farmyard manure. Apart
"from a somewhat more kindly physical condition shown by land
"receiving farmyard manure, the main difference between the
"dunged land and that receiving artificials lies in the extent of
"the residual effect which, as we know from certain Rothamsted
"experiments, is much greater with dung than with artificial
"fertilizers."

Rothamsted (heavy soil), Continuous Cropping.

Average yields per acre.

Manures to each crop.	Wheat.	Barley.	Mangolds.
	71 seasons.	70 seasons.	45 seasons.
No Manure	12 bu.	15 bu.	3½ tons
14 tons dung (approx. 186 lbs. N.)	34 „	46 „	18 „
Complete artificials :—			
(43 lb. N.)	22 „	41 „	...
(86 lb. N.)	31 „	...	18 „

Woburn (light soil), Continuous Cropping Since 1876.
Average Yields per acre, 1915-24.

Manures to each crop.	Wheat.	Barley.
No manure	8·0 bu.	9·6 bu.
7 tons dung (approx. 82 lb. N.)	20·6 „	27·7 „
Complete artificials (20 lbs. N.)	16·4 „	18·7 „

Saxmundham (heavy soil), Rotation Cropping.
Average Yields per acre, 1910-23.

Manures to each crop.	Wheat.	Mangolds	Barley.	Peas and Beans.	Cloverhay.
	13 crops.	13 crops.	12 crops.	10 crops	3 crops
No manure	18 bu.	5 tons.	17 bu.	20 bu.	32 cwt.
6 tons dung (72 lb. N.) ...	29 „	18 „	30 „	39 „	80 „
Complete artificials (30 lb. N.)	30 „	17 „	31 „	36 „	60 „

Bramford (light soil), Rotation Cropping.
Average Yields per acre, 1902-7.

Manure to each crop.	Wheat.	Mangolds.	Barley.	Peas.	Clover hay.
	6 crops.	6 crops.	6 crops.	3 crops.	2 crops.
No manure	19 bu.	12 tons.	27 bu.	31 bu.	37 cwt.
6 tons dung (72 lb. N.)...	2'½ „	16 „	38 „	29 „	33 „
Complete artificials (30 lbs. N.)	25 „	18 „	39 „	24 „	29 „

The figures obtained in the Rothamsted experiments are of the greatest interest because so long continued.

Here the soluble artificial manures, sulphate of amonia, sulphate of potash, and superphosphate have for seventy-one years

maintained yields nearly equal to those obtained by the use of farmyard manure supplying more than twice as much plant food. This would suggest that the farmyard manure is less efficient than the soluble artificial manure, and as a direct source of the most important plant foods, no doubt it is.

Annual application of a complete mixture of soluble artificials supplying 129 lbs. nitrogen, 80 lbs. phosphoric acid and 100 lbs. potash has at Rothamsted over 50 years, maintained an average yield of 36.9 bushels of wheat against 35.6 bushels from 14 tons farmyard manure estimated to contain 186 lbs. nitrogen, 78 lbs. phosphoric acid and 235 lbs. potash.

On the straw the difference is still more marked being 40.9 cwt. from artificials as against 33.9 from the farmyard manure.

The distrust of artificial fertilizers shown by British farmers when they were first introduced was very natural. The prejudice against them may now be said to have disappeared, although as Garner writes—"The accepted view is that artificials should be "used as a supplement to, but not as a substitute for, farmyard manure." It is time that the prejudice against soluble artificials which still exists among some of those interested in tea should disappear.

When, as at Rothamsted, sulphate of ammonia has been used for 71 consecutive seasons with the result quoted, it can no longer be argued that the results shown at first must be followed by disaster. That some knowledge is necessary in the use of artificials is exemplified by the facts that on soils poor in lime, the continuous use of sulphate of ammonia has rendered the soil eventually too acid to grow certain crops, and that at Rothamsted crops began to fall off when sulphate of ammonia was used without potash or without phosphates.

On such points sufficient knowledge is available to the tea industry, although many minor questions affecting manuring still require investigation.

In the case of tea we may take it as certain that if any soil is completely unmanured, the crop produced will fall to a very low level. If manuring is confined to the use of as little cattle manure as is commonly available, crop will not be maintained at a much higher level.

Proper combinations of artificials can be used to supply sufficient of the three absolutely essential plant foods (nitrogen, phosphoric acid and potash) to maintain high crops at a relatively low cost, even if no form of organic matter be applied.

If manuring were at any time stopped yields from the artificially manured soil would drop very rapidly back to those obtained from unmanured soil, while the crops on the soil manured with farmyard manure would decrease only slowly. It is estimated that, if manuring ceased, it would be 50 years before the crops from the farmyard manure plots at Rothamsted became equal with those from unmanured soil.

This residual effect however has been obtained at a very wasteful expenditure of nitrogen.

Russel publishes the following balance sheet :—

Nitrogen in soil in 1865 ... ·175% ...	4,340	lbs.	per	acre
Nitrogen added as manure, rain (5 lbs. per annum) and seed (2 lbs. per annum)	9,730	,,	,,	,,
Nitrogen expected in 1912 ...	14,070	,,	,,	,,
Nitrogen found in 1912 ... ·245% ...	5,730	,,	,,	,,
Loss of nitrogen from soil in 47 years	8,340	,,	,,	,,
Nitrogen accounted for in crops ...	2,550	,,	,,	,,
Balance being dead loss	5,790	,,	,,	,,
Annual dead loss	123	,,	,,	,,

The loss comes mainly from washing out of the soil nitrates formed from the cattle manure; but when such large doses of

dung are used there is some loss also from production of gaseous nitrogen due to "denitrifying bacteria." Such losses are unavoidable in "high farming." The richer a soil the more rapidly does it lose nitrogen.

There are two sources of natural gain of nitrogen in the soil, *viz.* :—bacteria associated with leguminous weeds, and certain free living bacteria, both of which fix nitrogen from the atmosphere. If never manured a soil would lose nitrogen till a point is reached when the rate of loss is counterbalanced by the rate of gain from these sources.

The unmanured plot at Rothamsted has reached this point.

Nitrogen in soil in 1865 .105 p. c.	...	2,720	lbs. per acre.
Nitrogen added in rain and seed	...	330	,, ,, ,,
Nitrogen expected in 1912	...	3,050	,, ,, ,,
Nitrogen found in 1912 .103 p. c.	...	2,510	,, ,, ,,
Loss from soil ...	...	540	,, ,, ,,
Nitrogen accounted for in crop	...	750	,, ,, ,,
Balance being gain of nitrogen	...	210	,, ,, ,,
Annual gain ...	...	5	,, ,, ,,

This plot may be expected to go on giving about 13 bushels wheat per acre without manuring; but manuring will show a profit whenever the value of the increased crop exceeds the expenditure on manuring.

The use of small annual dressings of artificials maintains a much higher state of fertility without very wasteful expenditure of plant food.

An artificial mixture providing 43 lbs. nitrogen (2 cwt. sulphate of ammonia) at Rothamsted has maintained for the last 71 years a crop of 22 bushels wheat against 12 for the unmanured plots.

Of this plot Hall wrote in 1905,—

" On Plot 6 only 43 lbs. of nitrogen are supplied, little more than the amount removed by the crop. If we consider the other

sources of loss of nitrogen to the soil, such as the removal of weeds, drainage, etc., it becomes clear that the 43 lbs. of nitrogen in the manure are not sufficient to repair the annual withdrawals of nitrogen. Consequently we should expect some diminution of fertility on this plot, and analyses of the soil seem to show that it is slowly losing nitrogen."

"The curve expressing the crop on plot 6. . . . indicates a considerable fall in fertility during the first ten years and a comparatively constant position for the last 40 years. Thus this plot seems to have reached a position of comparative stability when the annual withdrawal of nitrogen is almost balanced by the additions from all sources, so that the fertility of the land is declining very slowly if at all."

On this plot therefore good crops are being maintained without any waste of manure.

Larger dressings of artificials can maintain a still higher level of fertility but only with a considerable waste of manure.

Tea which has never been manured for 40 years must have come very close to the point of balance, and if it continues unmanured may be expected to maintain its present yield unless so weakened that disease attacks it; but the yield is much less than the virgin soil yielded, and much less than could be obtained with moderate manuring.

Manures are now very cheap, while tea is still a very valuable crop. Manuring must pay.

Experiments show that it does, very handsomely. The following experiment at Borbhetta on three pairs of adjoining plots is an example.

The "M" plots received 150 lbs. sulphate of ammonia, 150 lbs. superphosphate, and 60 lbs. muriate of potash. The "U" plots received the potash and phosphate only which have been shown on other plots to make very little difference for the better when used alone. Tea's main requirement is nitrogen.

Yields in mds. tea per acre.

Comparison of manured with unmanured tea.

	1920.		1921.		1922.		1923.		1924.		1925.		1926.		1927.		Total gain for 7 yrs. manuring 1922-1927.	Average annual gain mds. tea per acre.
	M°.	U°.	U.	U.	M.	U.	M.	U.	M.	U.	M.	U.	M.	U.	M.	U.		
1	9·7	9·2	7·5	7·6	8·4	8·4	10·1	9·4	9·5	9·9	10·1	7·6	9·5	7·3	8·7	5·3	...	...
2	8·1	8·1	6·4	6·9	7·6	7·5	9·4	8·1	9·4	7·2	11·4	7·6	9·7	6·7	8·9	5·8	...	...
3	8·9	9·4	6·7	7·5	8·3	8·0	9·2	8·4	8·7	7·2	9·4	7·3	8·7	6·5	8·9	6·2	...	...
Average ...	8·9	8·9	6·9	7·3	8·1	8·0	9·6	8·6	9·2	7·4	10·3	7·5	9·3	6·8	8·8	5·8	...	...
Difference due to manure ...	...	...	...	...	0·1	...	1·0	...	1·8	...	2·8	...	2·5	...	3·0	...	11·2	1·6

*M = Manured.
*U = Unmanured.

Cropping previous to 1920 had indicated that the "M" plots were initially poorer than the "U" plots. In 1920 the manure applied made the plots equal in crop. In 1921 no manure was applied and the plots which had been manured dropped back. The tea was unpruned in 1920, but was top pruned in all succeeding years, hence the drops in 1921 as compared to 1920.

The 1922 manuring again made the plots equal in crop. In succeeding years increasing gains are recorded from manuring, due mainly to increasing deterioration of the unmanured plots.

The tea was planted in 1916 on old grazing land which was poor, but for a few inches under the thin turf had accumulated some reserve of nitrogen which by now must be nearly cropped out, so that little further soil deterioration is expected; but all plots on this poor soil are diseased, and the manured tea will probably resist disease the better.

At the end of 1925 the unmanured plots looked so poor that plucking was made lighter on all plots, in order to keep the check plots going. Otherwise yields from manured plots probably could have been maintained nearer the 1925 level; but the 30 lbs. nitrogen applied annually is not sufficient to save the soil from deterioration. 1927 was a bad year climatically while 1926 was exceptionally good : hence the big differences in yields for those two years.

The tea was very finely plucked and would have averaged at least 14 annas per lb. or Rs. 70 per md. in Calcutta. Increased costs for plucking, manufacturing, boxes, and freight probably would cost less than Rs. 20 per md. : so that the increased crop while on the bushes can be reckoned at, at least, Rs. 50 per md. The 1.6 mds. annual increase is therefore worth Rs. 80 at least.

Against this the manuring costs :—

		Rs.	As.
150 lbs. sulphate of ammonia at	Rs. 170 per ton ...	11	6
150 lbs. superphosphate at	Rs. 75 ,, ...	5	0
60 lbs. muriate of potash at	Rs. 135 ,, ...	3	10
Freight and carting on 360 lbs.	... ...	5	10
Application	... ...	2	0
	Total Rs.	27	10

Up to the present, then, the annual profit from manuring has been at least Rs. 52 per acre. For the future, profit will be greater because the average difference between manured and unmanured plots is likely to remain nearer to 3 maunds than 2 maunds.

If manuring were now stopped yields from the plots previously manured would fall back until they equalled those from the plots never manured.

At Rothamsted from plots manured with sulphate of ammonia in alternate years only, about 30 bushels are obtained in the manured years, and only 15 in the unmanured years. There is obviously very little residual effect from the manure since the plots never manured average about 13 bushels.

On tea, which occupies the soil for many years, differences would not be so marked; because although the residual effect in the soil is little, the improved bush left does not so rapidly fall off in yield, probably on account of an extended root range. In addition the prunings and leaf fall added annually help a lot in the maintenance of soil fertility. The cellulose so added feeds the bacteria which fix nitrogen from the air and thus add to the soil nitrogen supply. The addition of prunings also is followed by a disappearance of nitrate from the soil, which is accounted for as being used by the cellulose destroying organisms to build up their own bodies which afterwards die. The addition of soluble nitrogen after pruning therefore provides some organic nitrogen (as dead micro-organisms) part of which remains in the soil.

However it appears quite clear that soluble manures must be added annually, otherwise their cumulative effect is lost.

If manured only occasionally tea is likely to give significantly improved crops only in the manured years, and to fall very near to the plots never manured in those years when manures are not applied. We believe that the quite common distrust of "chemical manures" in tea cultivation, is due to the very common practice of giving big doses occasionally, when the subsequent falling off becomes so noticeable. There are many indications that such a practice, which entails that the bush grows alternately in very rich and very poor soil, upsets the whole food-supply system of the bush and increases liability to disease.

On the other hand we have every reason to believe that regular application of small quantities of properly balanced "chemical" manures, will maintain high *average* yields at a very cheap rate, and that larger quantities will produce increasing yields, even if no organic matter other than that provided by the bush itself is ever applied. Such a practice however is not advised.

Apart from the food it supplies organic matter improves the physical condition of the soil, a point of great importance to the health of the bush.

The advantages of a full supply of organic matter were fully dealt with by the Bacteriologist in this Journal 1927, Part III, page 115, and need not be repeated here.

These advantages are shown in practice on experimental plots in many places.

The wheat plots at Rothamsted to which no organic matter has been applied for 71 years, are very little affected in average crop, although the soil is gradually losing organic matter. Close examination of the figures, however, shows that the dunged plot maintains its yield well in dry years, while the crops from artificials fall much below their average. Tea has, annually, to pass

through a period of drought, and when such droughty periods are longer than usual, tea always suffers badly and its resistance to disease is seriously weakened. Much of the trouble from disease in droughty districts is, undoubtedly, due to this cause. The evil effects of drought can be greatly diminished by maintaining a soil's organic matter at a high level. It has been pointed out by C. M. Hutchinson that the alternative to manuring in India has too often been increasing cultivation which by stirring the soil increases the rate of formation of nitrates from the soil's organic matter and hence increases the rate of loss of this material which is so difficult to replace. Artificials can therefore be used to decrease the rate of loss of organic matter. The enormous majority of tea soils however would be much improved by a considerable increase.

Nitrogen, phosphoric acid, and potash also are not quite the only foods essential to a plant, and there is evidence that soils supplied with these only become gradually depleted of substances necessary to plants in minute quantities only and crops consequently decrease slowly. There is some evidence too, that cattle manure may contain, in very small quantity, substances analogous to the vitamines which are of such importance in human food.

Cattle manure is in every sense a complete food. It is advised therefore that as much cattle manure as can be obtained at reasonable rate should be applied. It should not however be applied in wasteful doses.

Analysis of the old, washed cattle manure used at Borbhetta is made annually. When "dry" (containing 50 per cent. moisture), that is, in its normal state as bought from villages in dry weather, it contains about—

.5 per cent. nitrogen
.6 per cent. phosphoric acid
.5 per cent. potash.

Since it may often be wetter than this we can take it roughly, that, 1 ton cattle manure supplies—

10 lbs. nitrogen
12 lbs. phosphoric acid
10 lbs. potash.

A dose of 20 tons provides 200 lbs. nitrogen. A crop of 10 mds. tea per acre uses 40 lbs. nitrogen. Of the remaining 160 lbs. the greater part is washed out in the first year, and the remainder stays in the soil to be partly washed out and partly used by crops in succeeding years.

If only 5 tons per acre is used, the wastage is very considerably less. If this quantity does not provide sufficient available nitrogen for the purpose in hand, the balance is better made up by a small additional dose of artificial.

5 tons cattle manure would provide 50 lbs. nitrogen, 60 lbs. phosphoric acid, and 50 lbs. potash. Its effect in the first year would be much less than that of the same quantities of food as soluble artificials, because so much less of it is available as plant food.

Used in small quantities however the food in cattle manure may be considered eventually to be nearly as valuable as that supplied as artificials.

One ton cattle manure may then be considered to supply plant food worth—

		Rs.	As.
Nitrogen 0.5 per cent. at Rs. 8.5 per unit	...	4	4
Phosphoric acid 0.6 per cent. at Rs. 2.5 per unit	...	1	8
Potash 0.5 per cent. at Rs. 2.7 per unit	...	1	6
Total value per ton	...	7	2

It is usually obtainable at a much smaller cost even including the high cost of application; so that we may consider that the organic matter is obtained for nothing. At that price it is so

well worth having, that one can only advise the application of as much as is obtainable.

There is one objection to its use: it contains the seeds of weeds. On the few areas where good tea has grown so thickly and widely that no jungle grows under its shade, it would be unwise to use cattle manure which would necessitate cultivation. Such tea, however, would seldom need cattle manure. Loss of organic matter from a soil so fully occupied by bushes must be very slow, and is probably more than counterbalanced by the annual gain from leaf-fall and prunings.

Very little cattle manure is commonly available. The growth of shade-trees and of green crops is therefore advised up to the capacity of the available labour to deal with them without neglecting the suppression of weeds among the tea.

As with cattle manure, so with green crops. The quantity which can be applied to the soil is normally much below that which is necessary to maintain fertility. Nor would it be advisable to depend upon green crops as the main source of nitrogen in any case.

Green crops retard the growth of tea among which they are growing and there is a further set back to growth after they are hoed in. Gains from green cropping must therefore be slow.

The nitrogen supplied to the soil also does not show up in improved growth of the bush till at least 6 weeks after burial. Since growth of green crops will not start till rain falls, usually about the middle of March, burial of green crops cannot start till about the end of April; and since hoeing in must be spread over at least six weeks, it will not finish before the middle of June. This means that bushes receive no benefit till between the middle of June and the end of July.

There are definite experiments establishing the fact that application even of immediately available manures is enormously more valuable in April than in June; while the general indications are that available plant food is best supplied soon after

growth starts which means application of manure some time between mid-February and mid-April, depending upon manure, soil, and season.

As sources of nitrogen, therefore, it is absolutely necessary to depend mainly upon artificial manures.

It is not within the scope of this article to deal with the question of choice among the many artificials available; but it may be pointed out that it is not generally economically sound to use concentrated manures as sources of organic matter.

The commonest organic manures in use are oilcake and animal meal.

In the case of oilcake 8 mds. is a normal "maintenance" dressing per acre.

This would supply about—

29 lbs. nitrogen
12 lbs. phosphoric acid
6 lbs. potash.

and on the present market would cost about Rs. 24.

Using sulphate of ammonia, superphosphate, and sulphate of potash, plant food equal to 8 mds. oilcake would cost Rs. 13-8; so that when buying oilcake we may take it that roughly we pay Rs. 10-8 for about 8 mds. of organic matter. How much more could be obtained for the price in the forms of cattle manure and green crops!

Five mds. Acme animal meal would provide 28 lbs. nitrogen, 28 lbs. phosphoric acid, and 20 lbs. potash at a cost of Rs. 31-4.

Using the plant foods in soluble form the equivalent of 5 mds. animal meal would cost only Rs. 15-6.

There are cases where, even at high prices, organic manures are advisable, but as a general policy for average soils it is advised that dressings of cheap soluble manures should be applied

annually. These should be supplemented as far as is possible by cattle manuring and green cropping.

These bulky organic manures will serve as sources of organic matter to maintain the physical condition of the soil, and assist to maintain crops in bad seasons. They will also add a certain amount of slowly soluble nitrogen to build up a reserve against bad times when manuring might have to be stopped.

In connection with manuring the question of quality has always to be considered. A larger crop at a correspondingly reduced price would show no profit.

Of late years there has been a tendency to blame manuring whenever quality has fallen below what was hoped for. In particular the amount of stalk is very often stated to have increased since manuring became more general.

Since much harder rolling has become general in order to obtain stronger liquors, it would be more reasonable to connect hard rolling with any general increase in stalk which there may be. Hard rolling would be expected to strip off the black skin and expose red fibre; whereas stimulus to growth by manuring would be expected to decrease the proportion of hard banjhie and to yield more succulent shoots generally.

The composition of the leaf however can be changed by manuring. This change on very poor tea may often be for the better, but any over-rapid growth undoubtedly tends towards a change in quality for the worse. Manures therefore must not be used to increase the rate of growth from the existing number of shoots; but to enable a larger bush to remain healthy and sufficiently fed to maintain a larger number of yielding shoots.

Rushes of quickly grown leaf must be avoided.

Any tendency to decrease in quality from manuring can be made up for by plucking and to a certain extent by pruning, because these factors make more difference to leaf composition than manuring does. In the good yielding year 1926, the average

crop in the Brahmaputra Valley was 8 mds. per acre; yet many gardens produced 10 and 12 mds. per acre at prices well above the average. High yield is therefore not necessarily associated with poor quality.

In practice, the tendency is rather the other way. Gardens which manure heavily are usually found near the top of the market for prices. This is only natural. A garden which can make a good crop with good plucking can afford to pluck good leaf. On a deteriorating soil the temptation to keep up crop must tend towards coarser plucking. Generally speaking the poor teas come from such soils: although they come also from very rich soils (such as bheel soils) where growth is very rapid.

Moderate regular doses of properly balanced manures should maintain good bushes which will produce good crops of good tea. Such good bushes can be plucked more closely, can be less heavily cleaned out, and need be heavy pruned less often. These factors count for a great deal in the production of good teas.

NOTES ON THE GROWTH OF YOUNG TEA PLANTS AND ITS RELATION TO RED SPIDER ATTACK.

BY

E. A. ANDREWS.

In the early part of 1927 a small nursery was established at Tocklai to provide plants with a known history for work in connection with susceptibility to disease. Careful observations of the development of these plants have been recorded, and although this was mainly done for subsequent reference when studying the behaviour of the plants, the observations afford certain information on the behaviour of tea in its early stages. Very little has been published on this subject, and it may be therefore not without interest to put on record the results of the observations.

The seed used was of light-leaved Assam " jat." 100 seeds, on being tested in the usual manner, gave the following results :—

	Sinkers.	Floaters.	Total.
Healthy seeds ...	95	1	96
Seeds punctured by the tea-seed bug, but not infested with fungus ...	2	—	2
Seeds infested by pathogenic fungi ...	2	—	2

Taking 2 " starred " seeds as equivalent to 1 good seed, and discarding infected seed as bad, the seed was therefore 97 per cent. good.

The average weight of each seed was 1.98 grams, which gives 18,327 seeds to the maund of 80 lbs.

Germination.—396 seeds were set to germinate in damp sand on January 25th. These were taken up for planting on February 24th (30 days later).

By that date 305, or 77 per cent. of the seeds, had germinated, the remainder being ungerminated. Of the germinated seeds,

88, or 22 per cent. of the whole, had made root-growth of 1 inch or more.

89, or 22 per cent. of the whole, had made root-growth of ½ inch or more, but less than 1 inch.

46, or 12 per cent. of the whole, had made root-growth not attaining ½ inch.

82, or 21 per cent. of the whole, had cracked only.

Plants obtained.—It is interesting, in view of the above figures, to take stock of the plants obtained. Observations were made towards the end of April, as marking the growth at the beginning of the rainy season (and to include the "chota barsat"), and again in the middle of October, as marking the end of the rainy season. 256 germinated seeds had been planted in February, and 16 ungerminated seeds.

187 of the germinated seeds had thrown up plants by the end of April, *i.e.*, 73 per cent. of the germinated seeds planted. 6 of the ungerminated seeds had thrown up plants, *i.e.*, 37½ per cent., though the number is too small for this latter figure to be of much value.

By the middle of October, there were 164 plants still standing from the germinated seed, or 64 per cent., while 6, or 37½ per cent., were still standing from the ungerminated seed. After the inspection in April, vacancies were filled in with 49 germinated and 30 originally ungerminated seed, of which 44 gave plants. Some of the latter seed had germinated in the meantime, and unfortunately the record was not kept of which was which. In the end, however, 214 plants were obtained from 351 seeds, of which 305 had germinated, and 46 had not germinated, at the original time of planting.

The figures for this result are :—

Seed germinated at original time of planting ... 87 per cent.

Plants obtained at end of first rains ... 61 ,,

that is to say, the number of plants obtained at the end of the first rains was 70 per cent. of the number of seeds which germinated in 30 days.

Of the 214 plants,

93 were good plants (10 inches and upward in height)

77 ,, fair ,, (6 to 10 inches)

77 ,, poor ,, (less than 6 inches)

i.e.,—26½ per cent. of the whole were good plants

22 ,, ,, ,, fair ,,

12½ ,, ,, ,, poor ,,

i.e.,—from 1 maund of seed would have been obtained 5,057 good plants—just enough to plant 2 acres 4 ft. 6 in. triangular, and 4,032 fair plants—enough to plant 1 3/5 acre.

The Soil Factor.—The soil in which the seeds were planted was by no means ideal for a nursery. It had been under tea before, and, since uprooting the tea, had been divided into 1 null plots, all of which had received different treatments at one time or another. This arrangement of plots was maintained when planting the nursery, and the growth made by the plants in different plots was exceedingly varied. An attempt to compare the growth obtained in the various plots was made as follows. Each good plant (10 inches or more in height) was weighed with the number 3, each fair plant (6 to 10 inches) with the number 2, and each poor plant (less than 6 inches) with the number 1.

In a plot in which every plant was a good one the growth was taken as 100 per cent., and the percentages for the plots calculated on this. The following are the figures obtained :—

2B	66.7
2C	72.9
3B	79.2
3C	27.1
4B	87.5
4C	89.6
5B	77.1
5C	56.2
6B	77.1
6C	56.2
7B	54.2

7C	35.4
8B	50.0
8C	56.2
9B	20.8
9C	52.1
9D (ungerminated seed)	29.2

The great variation in growth in different plots is well shown in the table, being from 90 per cent. to 20 per cent.

Most of the area had received lime at various times in the past, and acidity tests made on adjacent plots throughout the season had shown the soil to be too little acid for tea to do really well. Samples of soil were therefore taken from three plots, the worst at one end of the series, the worst at the other end of the series, and the best plot, and tested by the Chemical Branch of the Department for acidity. The percentage growth and acidity figures are given below :—

Plot.	Percentage Growth.	Hopkins Acidity.	pH direct.	pH of nitrate of potash extract.
4C	89·6	196	5·7	4·4
3C	27·1	49	6·0	5·0
9B	20·8	35	6·0	5·2

and show distinctly that the degree of acidity of the soil in the different plots has had a great influence on the growth obtained, the soil in the best plot being much more acid than in the other two, while in the better of those two the soil is a little more acid than in the other.

This tendency towards neutrality in many of the plots has undoubtedly had an effect in reducing the amount of growth obtained, and also, probably, in actual reduction of the number of plants obtained, for in certain cases seeds which had germinated very strongly at the time of planting failed to give plants as will be seen from the account, given below, of the relations between the vitality of the seed at the time of planting, as measured by root-growth, and the vitality of the plants at the beginning and end of the rains, as measured by height.

The Effect of the Initial Vitality of the Seed.—As stated above, the seed did not germinate evenly, and at the time of planting the seed was classified into five distinct grades, according to the degree to which development had proceeded. It is interesting to compare the growth made by plants from each grade of seed at the beginning and end of the rainy season, and this is shown in the following table. In this table the plants obtained from each grade of seed towards the end of April and at the middle of October are graded according to the growth made, and the numbers expressed in percentages of the number of seed in each grade.

	Growth shown by seed when planted.				
	Rootlet 1″ or more.	Rootlet ½ to 1″.	Rootlet less than ½″.	Cracked.	Ungerminated.*
Development by April 22nd.	%	%	%	%	%
4″ and more in height	8·0	6·7	2·2	0·0	0·0
3″—4″ „ „	31·8	19·1	4·3	3·0	0·0
2″—3″ „ „	32·9	21·3	21·7	15·1	6·2
1″—2″ „ „	11·4	13·5	13·0	15·1	25·0
0″—1″ „ „	3·4	10·1	17·4	21·2	6·2
Appeared later	0·0	1·1	0·0	3·0	0·0
Dead	12·5	28·1	41·3	42·4	62·5
Development by middle of October.					
10″ and more in height	42·2	34·8	26·9	15·1	6·2
6″ to 10″ in height	27·3	16·8	13·0	21·2	18·7
Less than 6″ in height	8·0	11·2	10·9	12·1	12·5
Dead	21·6	37·1	50·0	51·5	62·5

* These percentages are hardly comparable, as the number of ungerminated seeds planted was much less than the number of germinated seeds. They do show, however, that some of the backward seeds gave better plants than some of the forward seeds, and are included in the table on this account.

The results in this table show clearly that the greatest percentage of good plants has been obtained from the seed which germinated most strongly and that the percentage decreases on passing down the grades of seed, while the percentage of deaths increases.

Thus vitality of the seed to begin with is an important factor in the results obtained, a factor which even the extreme variation in soil conditions does not mask. At the same time, it is clearly evident that slow germination does not necessarily mean that a poor plant will be obtained, for some of the ungerminated seed has given good plants by the end of the rains, although the figures for April show that they were then behind the others. Soil conditions would of course produce this result, but as the ungerminated seed was planted at the worst end of the series of plots, it would appear that the result may accrue independently of soil conditions. The percentage of good plants obtained from the backward seed, however, is so small that the cost of planting and upkeep would hardly be repaid, and it is obvious that rapid germination in a consignment of seed is a necessary preliminary to the growth of a good nursery.

Growth during the Cold Weather.—It is well known that nurseries often make a good deal of growth during the cold weather. The cold weather just past was one in which, owing to the extreme drought, (at Tocklai only 7.41 inches of rain were recorded from the end of October to the end of April, against 19.76 the previous year), such growth might be expected to be at a minimum. Measurements of the height of the plants were made in the middle of April 1928, and we are thus able to record the growth made—1, from the time of planting to the end of the first rains, 2, during the rainy period of 1927, 3, during the cold weather 1927-28.

1. By the middle of October last the plants had attained an average height of 9.11 inches, with a maximum of 27.

2. During the rainy season (mid-April 1927 to mid-October 1927) the growth made was—average, 7.17 inches; maximum, 24½.

3. During the cold weather (mid-October 1927 to mid-April 1928) the growth made was—average, 5.73 inches; maximum, 15.

The plants were not watered, and indeed received no attention beyond forking in of the jungle. In the following table the growth made at the end of the cold weather is compared with that made at the end of the preceding rains.

Development by mid-April 1928	Development by mid-October 1927. Good 10 ins. and more.	Fair 6—10 inches.	Poor Less than 6 ins.
Very good, 24 inches and more ...	18·1%	......	......
Good, 18—24 inches	42·5%	15·6%	......
Fair, 12—18 inches	39·4%	45·4%	4·4%
Poor, 6—12 inches	......	35·1%	31·1%
Very poor, less than 6 inches ...	......	1·3%	31·1%
Dead	......	2·6%	33 3%

It will be noted that the plants which had shown the greater vitality right through give the largest proportion of good bushes, but that in each grade there is a percentage of plants which has overtaken some of the plants in the higher grades. It has to be observed, again, that such plants occur in the poor plots as well as in the better ones, so that here, again, the overtaking would appear to occur independently of soil conditions.

Vitality of Plant and Liability to Red Spider Attack.—Red Spider appeared on the plants towards the end of January, and continued well into February. In the middle of February the reaction of the plants to red spider attack was noted, and consideration of the observations made is not without interest.

The various plots, as shown above, differed considerably in the growth made by the plants. They were also found to differ considerably in their reaction to red spider, and the following table gives the percentage intensity of infection in each plot :—

Plot.	*Percentage Intensity of Infection.*
2B	35.3
2C	15.3
3B	18.7
3C	7.1
4B	16.7
4C	16.7
5B	35.5
5C	36.1
6B	23.3
6C	25.0
7B	12.5
7C	17.0
8B	25.0
8C	12.5
9B	3.3
9C	15.1
9D	12.5

Comparison with the growth table given above shows that, while the behaviour of the plants, on the whole, is irregular, the three plots with least growth (3C, 9B, and 9D) are the three plots with least red spider. This may, however, be mere coincidence, for plot 8C, with 56.2 per cent. of growth, has the same figure for red spider attack as plot 9D, with only 29.2 per cent.

As all observations have been recorded for each individual bush, however, it is possible to correlate red spider attack with growth made by the plants at the end of the first rains, at the

beginning of the rains, and when planted as seed. When this is done the following results are obtained :—

Growth by mid-October.	*Percentage Insity of Red Spider Attack in February.*
Plants 10 inches and more	... 24.7
,, 6 to 10 inches	... 19.1
,, less than 6 inches	... 8.0

Growth by mid-April	*Percentage Insity of Red Spider Attack in February.*
Plants 4 inches and more	... 26.0
,, 3 to 4 inches	... 25.5
,, 2 to 3 inches	... 21.1
,, 1 to 2 inches	... 16.7
,, less than 1 inch	... 15.1

Development of seed when planted.	*Percentage Insity of Red Spider Attack in February.*
Root 1 inch or more	... 21.0
,, ½ to 1 inch	... 23.2
,, less than ½ inch	... 19.7
Seed cracked only	... 17.9
Ungerminated	... 17.2

Thus, red spider attack was worst on—

plants of which the seed was best developed at the time of planting.

plants which were best developed at the beginning of the season.

plants which were best developed at the end of the season.

As we turn from the plants showing vigorous growth to those showing less vigorous growth it is found that the intensity of red spider attack diminishes. This is certainly not the result that would have been expected by the majority of planters, and there is no evidence to show that these results would be obtained under different

circumstances. In this case, however, the observations show definitely that it was not the bushes which one would call "weak" that got most red spider, but rather the reverse.

Conclusion.—The above observations are not recorded as being the result of exhaustive experiments on the growth of young tea. The observations were made, more or less by the way, in connection with other work, and are recorded, for what they are worth, as being suggestive, rather than instructive, with regard to a matter on which little or no information is available.

The figures given for the percentage of plants obtained are probably lower than is normally the case, as not only were soil conditions inferior, but the seeds were sown three feet apart, so that the shading effect obtained by close planting in a nursery was lacking. On the other hand, the figures do definitely show that

1. Other things being equal, the seed which germinates quickest gives the biggest proportion of good plants.
2. Soil conditions, as evidenced by acidity, have a great effect on growth, decrease in acidity producing decreased growth.
3. Growth in the cold weather follows the same course as in the rainy season, in that the most vigorous plants make most growth, and the difference in the development of a plant at the beginning and end of the cold weather may be considerable.
4. Slow germination does not necessarily mean a poor plant. Plants which lag behind to begin with may overtake plants which are further forward at any time during the first rains or the succeeding cold weather, and this apart from the fact of their being planted in better soil.
5. In this case, vigour, as measured by growth, did not mean increased resistance to red spider, but rather the reverse.

MOISTURE CHANGES DURING THE MANUFACTURE OF BLACK TEA.

BY

C. R. HARLER.

Fresh tea leaf, as it is plucked, contains about 77 per cent. moisture and finished black tea about 6 per cent. During manufacture water is lost from the leaf at varying rates and it is instructive to consider these losses.

Moisture loss during withering.

During the withering process the leaf loses moisture and becomes flaccid. This loss is necessary if the leaf is to be suitably rolled, but it is also the main factor in bringing about the changes going on within the leaf which constitute the chemical wither.

The degree of the chemical wither is influenced by time, temperature and the amount of drying of the leaf. Each of these factors may be varied within limits. Experience has shown that withering temperatures much above 90°F. are likely to harm the tea. It has been observed that very rapid drying of the leaf does not give such good results as steady drying. It is also well known that leaf kept much above 24 hours is liable, especially in the rains, to go sour.

So far as practical experience goes in North-East India it has been noticed that, during the rains, when the average temperature is about 83°F., the best tea is made from leaf withered in a cool place till it contains about 66 per cent. moisture. The length of time of the wither is limited because the leaf goes sour after a time. On the other hand the time may not be reduced beyond a certain limit for, although the physical wither may be obtained in two or three hours, it takes much longer than this for the chemical wither to develop.

The amount of drying during withering has an important influence on the kind of tea made. Hypothetically, it is possible to produce the same chemical state in the leaf without drying as with it, but, even if this state of affairs be realised, the

subsequent course of the chemical reactions which constitute fermentation is influenced largely by the physical condition of the leaf. A turgid leaf is smashed in the roller whilst a flaccid leaf is rolled. Estimations show that the rate of change of the tannin bodies in the smashed leaf is very different from that in the rolled leaf. It is also possible that the nature of the change is different in the two cases.

All leaf does not contain the same amount of moisture as it comes from the field. Quick growing shoots contain more moisture than slow growing ones, and tea grown in the shade contains more moisture than that grown in the open. During the season, leaf plucked from a certain plot at Tocklai showed the following average moisture percentages each month. The shoots plucked consisted of regular two leaves and a bud.

May ...	Average moisture in leaf	...	76.0 %
June ...	,, ,, ,,	...	77.3 ,,
July ...	,, ,, ,,	...	78.7 ,,
August	,, ,, ,,	...	77.0 ,,
September	,, ,, ,,	...	77.5 ,,
October	,, ,, ,,	...	77.9 ,,
November	,, ,, ,,	...	77.5 ,,

The dryest leaf was collected in May when one plucking showed a moisture content of 75.7 per cent. In July one plucking consisted of leaf containing 81.0 per cent. of moisture.

In order to obtain the correct physical wither, leaf has to be dried according to its original moisture content. The table below shows to what extent 100 lbs. of fresh leaf must be dried in order that it shall contain 66 per cent. moisture.

Moisture content of fresh leaf.		Degree of drying necessary.
80 per cent.	...	100 lbs. should dry to 60 lbs.
77 ,, ,,	...	100 ,, ,, ,, 69 ,,
75 ,, ,,	...	100 ,, ,, ,, 75 ,,
72 ,, ,,	...	100 ,, ,, ,, 84 ,,

Leaf rarely contains less than 75 per cent. moisture at any time and 77 per cent. may be taken as a safe average. Three

leaves and a bud contain about the same moisture percentage as a finer plucked shoot, but the coarser the leaf the longer it takes to wither physically.

Although the chemical wither must vary with each change made in the three controlling factors, temperature, time and drying, the average temperature is fairly constant during the rains and the time of withering is approximately 18 hours. With these two factors thus loosely defined the best check on the wither is kept by weighing the leaf. For this purpose, a rack in a typical part of the loft or a bay in the leaf house may be spread with leaf which is weighed before and after the withering period. In a very short time, the man in charge of the factory will thus learn what constitutes the degree of drying necessary for a good chemical wither. When this is accomplished the daily weighment of a typical rack may cease.

If the leaf is withered under control in a loft, the fans should be turned off after the necessary physical wither is obtained and a wait made for the chemical wither to develop. If the leaf must be cleared and rolled before 18 hours elapse, in order to make room for incoming leaf, then the physical wither may be carried further than denoted in the table above. Exactly how much further cannot at present be indicated, however.

In order to know exactly what degree of wither is necessary it is essential to know the moisture content of the fresh leaf. This can only be determined by the method described later. Unless such a determination is made, it should be assumed that the fresh leaf contains 75 to 77 per cent. moisture when it arrives at the factory.

Moisture loss during firing.

During rolling and fermentation no loss in moisture should occur, although in practice, some drying takes place. Often watery juice is expressed from the leaf during hard rolling, but this usually signifies an insufficient physical wither. In the fermenting room the leaf sometimes dries slightly, but this may be obviated by suitable humidification.

During the first firing, the tea should be dried to at least 12 annas, *i.e.*, till it is crisp. At this state of dryness the moisture content is about 30 per cent. Our recommendations regarding the firing of tea include an initial temperature in the firing machine of 180°F. and a temperature of 120°F. above the top tray where the cooled, moist air leaves the firing machine. More important, however, than these suggestions is a need for the tea to be discharged at least 12-annas dry. Unless this is so, it indicates that the leaf has been stewing and, rather than this shall take place, it is preferable to raise the temperature of the firing machine, in order to be able to dry the leaf to 12-annas during the first fire.

Since the practice of lowering the initial firing temperatures from 220°F. to 180°F. has become general most factories are found to be under-machined. The shortage of drying space can however be overcome by raising the speed of the dryer fan. In this connection the following calculations are of interest. A big Empire Dryer can dry 20 maunds of rolled leaf containing 66 per cent. moisture to 10 maunds 12-annas dried tea containing 30 per cent. moisture in an hour, the machine running with an initial temperature of 220°F. When the temperature is lowered to 180°F., the output of 12-annas fired tea is reduced from 10 maunds to about 7 maunds per hour. If, however, the fan speed is increased from 450 to 500 r.p.m., the air blast is increased in the ratio of almost 4 to 5. The output of 12-annas fired tea at 180°F. is similarly increased, and difficulties owing to machine shortage are largely overcome.

During the second firing the tea is dried to about 4 per cent. moisture, although during sorting this value usually rises to about 6 per cent. The moisture changes during manufacture in the rains may be tabulated as under :—

Fresh leaf ...	contains about	77	per cent.	moisture.
Withered leaf ...	,, ,,	66	,,	,,
First fired tea ...	,, ,,	30	,,	,,
Final ,, ,, ...	,, ,,	4	,,	,,
Packed tea ...	,, ,,	6	,,	,,

On these figures, 100 lbs. of leaf will produce just under 24½ lbs. of tea of all grades.

Moisture changes during sorting.

The rate and conditions under which tea picks up moisture have been studied by Deuss in Java (1). He placed different grades, both leaf and broken, into vessels in which the atmosphere was kept at different degrees of humidity. The teas were prepared so that they contained approximately 0, 2, 4, 10—12 and 14—16 per cent. moisture. The closed vessels into which the samples were placed were regulated to the following atmospheric conditions :—

(1) Over quicklime	... Relative humidity of air ...	0 %
(2) Over 70 % sulphuric acid	,, ,, ...	9 ,,
(3) Over saturated solution of calcium chloride	,, ,, ...	30 ,,
(4) Over 43 % sulphuric acid	,, ,, ...	50 ,,
(5) Over water	,, ,, ...	100 ,,

Further samples were exposed to the air of the laboratory where a self-registering hygrometer showed the humidity to vary between 70 and 80 per cent.

The gain or loss in weight of the samples was determined daily, and the results were found to be the same for all grades of tea. Over quicklime all the teas lost moisture, tending to a minimum of ½ per cent., irrespective of the original moisture content of the sample. The loss was greatest during the first two days.

With a relative humidity of 9 per cent. (over 70 per cent. sulphuric acid) the loss of water was less pronounced. In atmospheres of 30 per cent. and 50 per cent. humidity, all the teas, even those which contained only 4.7 per cent. moisture, still lost water.

The teas kept in a saturated atmosphere (humidity 100 per cent.) all absorbed moisture, even those which originally con-

(1) Deuss 1 J. J. B.—Over het water aantrekkend vermogen van thee—*De Thee*, Sept. 1926, pp. 97-101.

tained 14-16 per cent. Within six days the moisture content had risen to 26.5 per cent. in some cases.

In the atmosphere of the laboratory (humidity 70-80 per cent.) Deuss found that teas which contained 14.8 to 15.8 per cent. moisture, lost water. Those containing 1 to 9.9 per cent. moisture, absorbed water from the air. When the humidity of the atmosphere fell to 55-60 per cent., all the teas began to lose moisture again only to reabsorb it when the humidity of the air rose to 70-80 per cent.

It may be concluded from the above, that ordinary tea, which has a moisture content of about 4 to 8 per cent., will keep its moisture value fairly constant in an atmosphere of relative humidity 60-65 per cent., so that the latter should be the relative humidity of the sifting room.

Deuss suggests that the humidity of the sifting room be controlled by drawing in warm air from the drying room.

In North-East India it is common to *gap* or *pukka bhatti* the tea before boxing by passing it quickly through a dryer at about 150°F. This we consider to be necessary if the tea contains more than 6 per cent. moisture, but, in the majority of cases where moisture estimations have been made, it has been shown that final firing is not necessary. If leaf is dried to about 6 per cent. and sorted in a room where the relative humidity is 60-65 per cent., no appreciable extra moisture will be gained or lost during sorting. Wet and dry bulb thermometers should be placed in the sorting room and a check kept on the humidity. If the dry bulb is 85°F. then the wet bulb should read about 76°F., to indicate a relative humidity of 65 per cent. With dry bulb readings of 90°F., 95°F., and 100°F., the wet bulb should read 10°F. lower.

Although tea, during sorting, is liable to rapid changes in moisture content, tea stacked in heaps does not change much in a short time. Observations made in the Dooars have shown that the moisture content of the outer portion of the heap, a layer of

an inch or so, changes rapidly, but that, inside the heap, the change is negligible during the first day or two of stacking.

In North-East India it is usual to aim at 6 per cent. moisture in packed tea and to this end it is becoming common for tea factories to instal apparatus for accurately determining moisture. Observations carried on throughout the season at New Glencoe Estate in the Dooars (2) showed that in the early part of the season when " breaks " were made at long intervals, the tea often picked up so much moisture that a final fire was necessary before packing. In the rains, however, when tea was bulked and packed soon after it was made, the moisture content seldom touched 6 per cent. and final firing was unnecessary. In other factories the great value of moisture estimations has also been demonstrated.

Estimation of moisture.

Although many planters, with years of experience to draw upon, can decide, with some accuracy, whether a tea should be final fired or not, it is much more reliable, and certainly worth while, to estimate scientifically the moisture in tea before packing. Such an estimation may not only save an uneconomic final fire but also, by showing that a final fire is unnecessary, lead to an improvement in the tea which, if packed too dry, will not mellow or mature.

The apparatus required for moisture determinations is as follows :—

1. One chemical balance in case accurate to 0.005 gms.
2. One box of weights—50 gms. to 0.01 gms.
3. One copper steam oven, 23 cms.
4. One desiccator with porcelain plate, diameter 15 cms.
5. One dozen porcelain basin 6 cms. diameter.
6. Five pounds calcium chloride for desiccator.
7. One Primus Stove.

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(2) We are indebted to Mr. Haines of New Glencoe Estate for very full moisture estimations made during the 1927 season.

The cost of this apparatus, which may be purchased in Calcutta, is under Rs. 200.

The moisture content of leaf or of tea is estimated by completely drying a weighed quantity of the substance in an oven heated to 100°C. by boiling water. The dried sample is then weighed and the loss, which constitutes the water driven off, is calculated. Detailed steps of the estimation are as follows :—

1. Accurately weigh a clean porcelain basin to the nearest 0.01 gm.

2. Take a fair average sample of tea and weigh accurately into the basin 10 gms. of same.

3. Place basin and tea in steam oven in which water is kept boiling by a Primus stove or other suitable means. Keep in oven for two hours.

4. Take basin and tea from oven and put in desiccator to cool over calcium chloride.

5. Weigh cooled basin and tea quickly.

If this operation is not carried out in a few minutes the tea, being hygroscopic, will pick up moisture and increase in weight.

6. Put basin and tea back into steam oven for an hour. Cool and weigh again.

If second weight differs by more than 0.2 gms. from the first, put basin back into oven for an hour, cool and weigh again.

The calculations are made as follows. For example :—

Weight of basin ...	...	24.23 gms.
,, ,, + tea ...	...	34.23 ,,
Weight of tea ...		10.00 ,,
,, ,, ,, after heating (1)	...	33.88 ,,
,, ,, ,, ,, ,, (2)	...	33.87 ,,
Weight of dried tea ...	...	9.44 gms.
Loss in weight	...	0.56 ,,
Moisture	...	5.6 per cent.

The desiccator is a glass vessel with a glass lid, rendered close fitting by a little grease. In the bottom of the vessel is a space for calcium chloride, which keeps the air within the dessiccator dry. The basin and tea must be cooled before they are weighed, otherwise accurate weighment is impossible.

The apparatus is not only of use in determining the moisture of finished tea but also in checking the moisture percentage of the first fired tea and of the fresh leaf.

In Java it is becoming the practice in tea factories to estimate the moisure in tea before it is packed. In that country a somewhat different method of estimation is employed. Twenty-five grams of tea are placed in a copper flask with toluene, and the mixture boiled. The vapours, consisting of steam from the moisture in the tea and toluene, are condensed and returned to a graduated tube, in which the water sinks as a layer below the toluene. The volume of water is easily read off in the tube and the moisture percentage in the tea calculated.

COLD WEATHER SPRAYING.

BY

A. C. TUNSTALL.

It has now been generally accepted as a result of experience that spraying with lime sulphur solution is a valuable addition to the general routine of tea culture in North-East India. Unfortunately it is rarely possible to spray the whole area of a garden without undue interference with other equally important work. It is therefore necessary for the managers concerned to select which blocks they will spray. The object of this article is to help planters to make this selection.

First of all there are some diseases which, if not treated directly by the application of fungicides, will cause serious losses. It will always pay to spray tea which is attacked by such diseases even when the attack is slight. There is no difficulty in making a decision in such cases. It is where there is no disease of this nature that it is sometimes hard to decide which section should be selected for spraying.

It is necessary to have a clear idea of the work which spraying with a fungicide such as lime sulphur solution is intended to do. The lime sulphur solution will kill the fungi with which it comes into contact. It has no power to kill fungi which are in such a position that the fungicide cannot reach them. A fungicidal spray fluid therefore has no direct effect on fungi already present inside the tissues of the plant but it may of course be helpful in preventing these fungi getting into the tissues by killing these before they enter. In this manner it tends to reduce the amount of disease attacking the woody portions of the plant by protecting the wounds. Once a fungus is within the woody tissues of the plant the application of a fungicide has no direct influence upon it. It is therefore useless to spray a tea bush with rotten branches with the object of killing the fungus producing the rot.

There are however many fungi which cause considerable damage to the plant without penetrating so deeply that a fungicide applied externally will have no influence upon them. Examples of this type of fungus are those causing Thread blight and Black rot. While the fungi which cause Brown blight, Grey blight, Blister blight only remain immersed in the tissues for a comparatively short time. The application of lime sulphur solution by reducing these fungi improves the health of the bushes and so indirectly helps to reduce loss due to other fungi. The diseases which are most readily influenced by spraying are those which attack the younger portions of the plant, particularly the green portions. If all the younger portions are cut off as in heavy pruning the possible benefit likely to accrue from spraying is very limited. If applied immediately after pruning it is more or less confined to the temporary protection afforded to the wounds. It is therefore unlikely that any spectacular increases in crop will result from spraying heavy pruned tea. Unless such tea is badly hidebound or it is known to have been infected by a dangerous disease such as Black rot before pruning it may be left out of the spraying programme. The same applies to stick pruned tea.

The best results from spraying may be expected from tea which bears the maximum amount of young growth, *i.e.*, top pruned or unpruned tea. Unfortunately such tea is much more difficult to spray and the fluid required per acre is often more than double that required for stick pruned and heavy pruned. On this account many planters only spray the heavy pruned and stick pruned areas. This is a mistake although the cost of spraying such areas is less the increase in crop as a result of the spraying is also less and the profit per unit of money invested is not so great.

On most gardens more than half the area is top pruned or unpruned annually and it frequently happens that it is impossible to spray the whole of this area. It is therefore necessary to make a further selection. If a disease known to be likely to cause serious loss is present on any of the sections concerned it is of

course obvious that those sections should be chosen for spraying and it would be better to arrange to spray those sections twice rather than a larger area once.

Where no special disease is present it is well to select the areas expected to give the highest yield. Experience has shown that the greatest increase is likely to be obtained from the highest yielding areas while the cost of application is approximately the same. After all the object of all operations on a tea garden should be to obtain profit. The reduction in the amount of disease present on a particular area is only undertaken with a view to increasing profit. In the case of the commoner diseases such as Brown blight, Grey blight, Red rust total eradication is quite out of the question and unless the cost of special operations for their reduction is likely to be balanced by the value of the increased crop it would be more profitable to confine one's attention to other methods of increasing crop such as manuring, resting, etc.

To make this point clear let us consider two sections neither of which are attacked by a particularly dangerous disease but both attacked by the usual mixture of Brown blight, Grey blight and Red rust. In the one section the bushes have poor frames, say 10 per cent. of vacancies, and only yielding a total of five maunds of tea per acre. Assuming that the reduction in blight brought about by spraying will yield 10 per cent. more leaf (this is a reasonable figure) this only means half a maund of tea per acre. This increased profit may in some cases barely cover the cost of spraying. It would probably pay better in those cases to spend the same amount of money and labour on increased manuring, filling in vacancies and increasing the vigour of the bushes by leaving the poorer ones unplucked. In the case of a section yielding ten maunds per acre however an increase of 10 per cent. due to reduction in blight would always pay a handsome profit on the cost of spraying. It is therefore suggested that in the absence of disease likely to assume epidemic form under conditions favourable to the parasite concerned spraying should be

limited to areas on which an increase of 10 per cent. in the crop will pay good profit on the cost of the operation.

On most gardens it is difficult to find the necessary labour for spraying on a large scale except during the period between the completion of the pruning and the commencement of the plucking. This is fortunately the best season for the application of fungicides to top pruned and unpruned tea. It is however unsuitable for the treatment of heavy pruned and stick pruned bushes as the presence of the tender shoots renders it necessary to reduce the strength of the solution applied. Where it is desirable to spray such tea the spraying should be carried out immediately after the pruning of the sections concerned. Where a disease such as Black rot has been present on the tea before it was pruned a second application should be made after the removal of the first flush. This should also be made in the case of unpruned and top pruned sections where diseases of this nature have been present in the previous season. Where no serious disease has been found it usually pays better to spray a larger area once than a smaller area twice.

In all cases, however, it is of the utmost importance to see that the work is properly done. The manager himself or a responsible assistant should ascertain by experiment the amount of fluid necessary to cover every part of a number of bushes representative of each type of pruning completely and thus estimate the amount of fluid required per acre in each case. If this item is known it is comparatively simple to check the work. The success of the spraying depends first on the preparation of the fluid and secondly on the completeness of the covering of the bushes with a film of the fluid. For purposes of estimating the amount of fluid required per acre the figures given in "Quarterly Journal," Part IV, 1926, may be taken but those figures are only useful for that purpose. The actual amount required must be ascertained by experiment on the sections concerned.

The preparation of the concentrated fluid needs care. The principal difficulty is the lime. Unless good quicklime can be

obtained it is better to buy the solution ready made from Calcutta chemical firms. A solution of 30° Beaume concentration may be obtained at Rs. 2 per gallon. If good quicklime can be obtained it is certainly much cheaper to make the solution on the garden, but it is necessary to supervise the manufacture carefully. Details of the manufacture and the dilution necessary for both home made and ready made concentrated solutions may be found in " Quarterly Journal," Part IV, 1926.

The question is often asked whether it is possible to make a more concentrated solution on the garden. It is quite possible but on account of the additional supervision required it is not practical. When preparing very concentrated solutions extreme care is necessary both in the purity of the materials and in the methods employed. For instance, the temperature and time of boiling require to be exact—too short or too prolonged boiling will give a different concentration. The easiest way to prepare the concentrated fluid is by injecting steam from a boiler. It is however necessary to use a thermometer to ascertain when the liquid is actually boiling as it is impossible to say whether the fluid is actually boiling when steam is bubbling through it.

To ensure even distribution of the fluid it is essential to have the machines in good condition. It is particularly important to see that the nozzles produce a film mist-like spray. Too often the apertures have become worn and the spray is too coarse. It is a good plan to replace the nozzle apertures every year. The hole should not be much larger than that made by a large size darning needle and the spray produced should be fine enough to float on the wind. Within limits the finer the spray produced the more efficient the spraying. It is obvious that more fluid will be used to cover the bush if the drops are large. The object in view is to obtain an unbroken film of fluid over all parts of the plant. Nothing is gained by putting on more than this as it will merely run off into the ground.

To do spraying economically it is necessary to think out the organisation carefully. Unless this is done a great amount of

time and money may be lost. For this reason it is desirable to restrict the spraying to a comparatively small area in the first season and in future years utilise the experience gained when a large area may be undertaken. It is foolish to attempt to spray the whole area of a large garden in the first season unless the presence of a serious disease makes it imperative.

While it is safe to assume that not less than 10 per cent. of the total crop in North-East India lost annually from the combined effects of the diseases caused by the commoner vegetable parasites could be saved by spraying it does not follow that it would pay to spray the whole area as in some cases the cost of the application would exceed the value of the tea saved.

To summarise—

1. Spraying with a fungicide will only directly influence vegetable parasites with which it may come into intimate contact.
2. It is useless against parasites which are at the time of application immersed in the tissues of the plant.
3. Under ordinary conditions most of the diseases likely to be influenced by spraying are removed when a bush is heavy pruned or stick pruned. The benefit likely to accrue from spraying is therefore limited to the temporary protection of wounds, the softening of hide-bound bark and the removal of such parasitic fungi, *e.g.*, Thread blight, Black rot fungus, which may be present outside the old bark.
4. Spraying is likely to be most beneficial to top pruned or unpruned tea.
5. The highest yielding sections are likely to give greater increases as the result of spraying than poorer yielding ones.
6. Where certain diseases likely to cause serious damage are known to be present it is desirable to spray the sections concerned under any circumstances.

7. Good quicklime is essential for the preparation of good lime-sulphur solution.

8. The solution must be boiled properly.

9. A fine spray is essential to efficient spraying and attention should be paid to the size of the apertures in the nozzles.

10. To obtain good results from spraying it is necessary to organise the work carefully.

A great deal can be learned about a section of tea by studying the yields for each round of plucking for the previous season.

If we plot the yields for each plucking of a light pruned or unpruned section on squared paper it is possible to identify the different flushes by the shape of the curve. By adding together the yields constituting each flush we obtain five or six numbers. If we divide these numbers by the area in acres of the section concerned we have the yield per acre for each flush. This can be done with the yields for each plucking for all the sections on the garden. If these figures are plotted on squared paper it is possible to compare sections which have been similarly treated. The difference between the curves of sections attacked by disease can often be seen at a glance and it is frequently possible to obtain some idea of the losses caused by particular diseases. If managers care to send the necessary information to Tocklai the writer is willing to work out the figures and make suggestions thereon. The following information is necessary :—

1. The yield for each round of plucking of
   (*a*) the doubtful section.
   (*b*) a similarly pruned section apparently healthy and vigorous.
2. The pruning and annual yields of each of the sections concerned for the previous five years.

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PLUCKING EXPERIMENTS AT BORBHETTA.

BY

H. R. COOPER.

Special interest attaches to results of a plucking experiment in the first year of the experiment. It is of great importance to have an idea of the probable immediate effect of any change from the normal plucking system. In the case of these experiments, therefore, a new method of conducting field experiments on tea was adopted, which it was hoped might prove more accurate than the usual method of averaging yields from a number of plots under the same treatment, but selected by chance, irrespective of previous yield.

These particular experiments were conducted on an area of Bazalony tea planted in 1919 at 5 feet by 5 feet triangular. The area consists of eight plots each containing eight lines of eighty bushes. Two lines of tea are missed between each plot, and in the intervals thus left are drains. The outside lines of each plot are therefore about seven feet from the edges of the drains, which are too far to cause the suffering of the bushes which is so noticeable on bushes close to drain-sides, at least in sandy soil. On the contrary the outside lines of tea gain so much from the wide strip of clean soil between them and the drains that they yield about 50 per cent. more crop than the average inside lines. The yields from inside lines vary unevenly.

Each of the 64 lines was plucked in the same manner, and the leaf weighed separately, during the seasons 1924, 1925 and 1926.

At the end of 1926 the lines were divided into 16 sets of 4 lines each, such that each set contained—

1 highly yielding outside line,
1 highly yielding inside line,

1 moderately yielding inside line,
1 poorly yielding inside line.

The lines forming each set were selected so that the sum of the yields from the four lines in each set was within 2 per cent. of the average yield of the 16 sets of four lines.

The four lines of each set, also, were scattered pretty evenly over the block of tea so that small seasonal variation in crop due to such factors as distance of land above water level should not affect any one set unduly.

The sixteen sets of four lines thus represent areas of the same variety of tea of the same age, which have been under similar treatment for seven years, have yielded very similarly for three years, and are similar in situation.

We have therefore reason to expect that if treatment had continued to be similar the yield would have remained very similar, and that differences found under different treatments are directly due to the effects of those treatments.

To measure the accuracy of this assumption two of the most important systems of plucking were each repeated on four separate sets. The yields obtained from these sets were in satisfactorily close agreement.

Plucking system.	Set No.	Yields in lbs. green leaf per 320 bushes 1927.	Average yield.
6" new wood and then to janum	2 11 12 13	761 734 745 748	747
6" new wood, then 1 big leaf, then janum	6 14 15 16	667 570 681 667	671

It will be observed that the maximum differences between the average yield and that of any one set under the same treat-

ment occur in the cases of sets 2 and 11 which differ from the mean yield by 14 lbs. or about 2 per cent. In the cases of the 6 other sets agreement is very close indeed. It may be assumed therefore that the experimental error of the result from any one set is not likely to exceed 2 per cent.

The tea was heavily centred early in 1921, cut at 20 inches and spaced out a year later, and top pruned since. Top pruning in 1926 and 1927 was absolutely flat, leaving a horizontal surface, one inch above the previous year's pruning : dead wood and banjhi shoots were removed but poor shoots if they showed more than two plucking marks were left.

In these experiments we are dealing with generally vigorous, mature, high tea. The results would not apply to the cases of low, or poor tea; and would not necessarily apply even to this same tea if it were differently pruned, or manured, or subjected to different weather factors.

In all these experiments two leaves and a bud only were taken; if any shoot showed three leaves above the position indicated by the system of plucking, the third leaf was broken back and thrown away. From any shoot which was *banjhi* the top leaf only, while still soft, was taken into the baskets; any second or third leaf from a *banjhi* shoot being broken back and thrown away ; these orders were, of course, not perfectly carried out, but accidental departures from them were infrequent. Plucking in every case was on Friday in each week.

In the tables are shown the total leaf plucked in each period of four weeks (sum of four pluckings). The results obtained are discussed below.

TABLE I.

Trial No.	PLUCKING SYSTEM.	LBS. LEAF PER 320 BUSHES (TO NEAREST LB.)										Mds. pucca tea per acre.
		April 8th to April 29th	May 6th to May 27th	June 3rd to June 24th	July 1st to July 22nd	July 29th to Aug. 19th	Aug. 28th to Sept. 18th	Sept. 25th to Oct. 14th	Oct. 21st to Nov. 11th	Nov. 18th end of season.	Total for year.	
1	4" new wood, then to janum	30	3	97	89	110	134	158	101	34	755	14·79
2	6" ,, ,, ,, ...	21	3	99	85	106	144	159	97	30	747	14·63
3	8" ,, ,, ,, ...	14	3	97	82	100	140	159	101	36	733	14·37
4	10" ,, ,, ,, ...	8	3	69	61	100	135	151	104	31	660	12·93
5	4" new wood, then 1 big leaf, then janum	27	4	89	60	106	133	143	100	32	693	13·59
6	6" ,, ,, ,, ...	20	3	87	51	110	124	144	104	30	671	13·15
7	8" ,, ,, ,, ...	14	3	83	57	110	125	148	102	30	672	13·17

(1) *Effect of Leaving Different Lengths of New Wood before Plucking.*

It will be seen from trials No. 1 to 4 (Table I) that during April when the first flush only was being taken, the closer the plucking the greater was the yield obtained. During May no system of plucking yielded any significant quantity of leaf, because growth of all bushes was then so stunted as to be practically stopped by what is generally described as "green-fly" attack. Only a few very small shoots were taken until the bushes "came through" in June. In June yields were almost identical whether 4, 6, 8 inches of initial growth had been left, but many shoots were going *banjhi* at about 8 inches, and did not reach the 10-inch level, so that crop from leaving 10 inches of new wood was reduced significantly. For the rest of the season there was very little difference in crop whether 4 inches, 6 inches or 8 inches had been left originally; but when 10 inches were left a further loss occurred in July when waiting for shoots to grow 2 leaves and a bud above 10 inches before plucking. After that crops were much the same from all four systems of plucking for the remainder of the season.

It would appear then from these trials that it makes little difference to crop whatever initial growth is given up to 8 inches, except very early in the season when collecting "tippings" of small value for tea making.

This result is confirmed in trials No. 5 to 7 when a big leaf is left after the first flush. Here again there is no very great difference in crop whether 4 inches, 6 inches or 8 inches initial growth is left.

It is very necessary to consider whether this result is of general application. It is generally expected among planters that sparing plucking early in the season will give more tea at the end of the season. The early close to the season in 1927 might have reduced the late crop from the more sparingly plucked bushes in these trials. The "green-fly" attack in May,

on the other hand, might have reduced the expected early crop from the more closely plucked bushes.

It is probable, however, that the total yields quoted are normal for the type of big, vigorous, leafy, well-manured bush used in these trials. On such bushes it probably does make only a small difference to final crop whether 4, 6 or 8 inches of initial growth is allowed. When ten inches were left there was a considerable difference because so many shoots went *banjhi* before reaching 10 inches, and took a long time to come through again and grow above the 10 inches level. From general observation it appears that shoots from different bushes go *banjhi* after different lengths of growth. Very poor bushes scattered among the tea of this experiment went *banjhi* long before they reached 8 inches. On another area at Borbhetta the check plots from a series of manuring plots gave 5.8 maunds tea per acre when plucked to 8 inches in 1927 whereas in the very similar season 1925 they had given 7.7 maunds when plucked to 6 inches. In 1927 the second flush was not being taken from these plots to any significant extent till the end of July.

When a shoot is going *banjhi*, the act of plucking (which is in effect a light pruning) stimulates fresh vegetative growth, and thus forces a fresh flush. This forcing must further debilitate a weak bush; while if the *banjhi* shoot is left to grow till new growth comes away, the effect must be to strengthen the bush considerably. Experiments at Tocklai over a series of years show most remarkable improvement in the appearance of bushes from which *banjhis* are never plucked. The present evidence therefore indicates that if a section of top pruned tea is plucked at 8 inches, there will be little loss of crop from the good bushes, while the poor ones will be improved very considerably. Good bushes may stand plucking to 6 inches, but little increase of crop is to be expected from the harder plucking of such good bushes. If poor bushes are plucked to 6 inches the probability is that they will lose vigour still more; while if poor bushes were plucked to 8 inches a loss in crop is to be

expected, but a gain in vigour sufficient to justify the loss of crop may be looked for.

(2) *Effect of Leaving a Big Leaf after Tipping.*

It has been pointed out above that crops, after May, varied little whether 4 inches, 6 inches, 8 inches initial growth were left: but, it will be seen from Table I that the leaving of a big leaf over the initial plucking causes a very considerable loss of crop.

In the cases of the trials leaving 6 inches initial growth, the experiment was repeated on four series of four lines each, both when plucking was afterwards immediately to the janum, and when a big leaf was left. The individual results from each set are quoted in order to give an idea of the probable accuracy of the averages (Table II).

TABLE II.

Effect of leaving of big leaf after 6 inches initial growth on crop during season.

	6″ to janum.		6″ then 1 big leaf then janum.		Loss from leaving leaf.
	lbs. ozs.	Mean.	lbs. ozs.	Mean.	lbs. ozs.
June 3rd to June 24th ..	102 7½ 100 2 98 6 94 0	98-12	92 4 84 6½ 81 14 80 0	87-4	11 8
July 1st to July 22nd ...	90 7 84 7 81 14 83 8	85-1	50 1 49 2 53 15 51 4	51-2	33 15
July 29th to August 19th ...	101 14 110 3 109 0 102 6	105-14	116 11 109 6 108 12 103 13	109-10	3 12 (gain)
August 26th to September 16th	147 11 139 7 144 10 142 11	143-10	119 4 126 12 125 3 126 11	124-8	19 2

	6″ to janum.		6″ then 1 big leaf then janum		Loss from leaving leaf.
	lbs. ozs.	Mean.	lbs. ozs.	Mean	lbs. ozs.
September 23rd to October 14th	166 2 154 7 159 10 154 8	158·11	145 7 143 6 142 2 145 9	144·2	14 9
October 21st to November 11th	96 9 101 2 93 12 95 0	96·10	98 11 105 14 103 9 107 7	103·14	7 4 (gain)
November 18th to end of season	21 13 31 9 34 11 31 14	30·0	34 13 29 1 28 15 27 14	30·3	0 3 (gain)
Total for year 1927 ...	760 10 748 1 745 4 732 4½	746·9	680 12 669 9 667 4 666 12	671·1	75 8 (or 10% loss for season)

The second flush was coming away early in June and carried on into July. During these two months it will be seen from Table II that there was a very marked loss of crop when a big leaf was left, while waiting for the extra leaf to grow and later probably because the more leafy bush received less stimulus to growth.

During the next four-week period (August), a slightly increased crop was obtained when plucking over the big leaf. This, however, was not maintained and the more leafy bushes flushed less strongly from the end of August till the middle of October. For the remainder of the season the bushes plucked over a big leaf gave slightly bigger crops than the hard plucked bushes. It is, of course, possible that if the "back end" of the season had not proved so much poorer than in average seasons, the more lightly plucked bushes might have made up more of the loss they had made earlier in the season.

In 1927 the loss from leaving a leaf over 6 inches initial growth, amounted to 10 per cent. of the crop, which on this tea is equivalent to a maund and a half of tea per acre. When

plucking to either 4 inches or 8 inches initial growth, the losses from leaving a big leaf were similar as will be seen from Table I.

When examining the bushes at the end of the season, it was not considered by any observer that there was generally any noticeable improvement in the appearance of the bushes from more sparing plucking applied by leaving a leaf. In following years, improvement may become noticeable.

When the bush is spared by leaving longer initial growth as long as 10 inches the improved appearance of the bush, and the greater thickness of the pruning wood was quite marked, even to casual observation, although the crop obtained (12.93 maunds) was little less than was obtained from leaving a big leaf over an initial growth of 6 inches (13.15 maunds).

On the whole, as far as one can guess from the limited evidence available, it is considered that if bushes require more sparing plucking (as a measure of renovation) it would be better to leave longer initial growth than to leave growth afterwards. If one plucks to 8 inches the poor bushes will go *banjhi* before they reach 8 inches and by the time they come away again, will be more spared than if growth be forced by plucking at 6 inches even though a leaf were left later.

The leaving of 8 inches on average tea (about $7\frac{1}{2}$ maunds per acre) would reduce yields greatly for a time. The average section in commercial practice is a mixture of good high bushes, and poor low bushes. The former generally get away and tend rather to be underplucked, the latter are generally badly over-plucked and get worse and worse. The very even sheets of tea at Tocklai and Borbhetta, and on many gardens, have been produced by plucking to a measure from the ground for some years at least This method ensures that the weak bushes are not plucked hard, until they can stand it.

Growth by end of Season after Tipping at Different Heights.

At the end of the season, twelve bushes in each line were measured to determine the total length of growth made during

the season above the pruning level, both in the centre and on the extreme outside. Six of these bushes were from the north end where the soil is good, and bushes consequently vigorous: the other six were from the south end, falling on a strip of poor soil carrying poor bushes.

The following results were obtained :—

TABLE III

Growth above pruning level during season.

(Each figure is the mean of 24 bushes; except those from 6 inches plucking which are means of 96 bushes).

Style of plucking.	Good bushes.		Poor bushes.	
	Central shoots.	Outside shoots.	Central shoots.	Outside shoots.
	ins.	ins.	ins.	ins.
4″ to janum ...	9·9	8·4	8·4	7·2
6″ ,, ...	10·9	9·6	10·0	8·0
8″ ,, ...	11·9	10·4	10·2	9·0
10″ ,, ...	13·9	12·6	13·6	11·6
4″ then 1 big leaf then janum ...	12·2	11·2	10·1	9·1
6″ ,, ,, ,, ...	13·1	11·6	11·4	10·0
8″ ,, ,, ,, ...	13·7	11·6	12·3	10·7

It will be observed that a difference of 2 inches in original plucking height makes a difference of only about 1 inch by the end of the season, except in the case of the 10 inches plucking which by the end of the season leaves the bushes about 2 inches higher than the 8 inches plucking.

It will be observed also that the good bushes had grown at least an inch higher than the poor bushes, and that the centres of all had always grown higher than the outsides by about an inch. These differences are due to differences in lengths of stalk between the last plucking and the new janum.

It will be seen also that the leaving of a big leaf makes a bush at the end of the season about two inches higher than when plucking to the janum on the same length of wood.

The measurements given can only be accepted as indications. There is a great variation between the heights reached by different bushes under the same system of plucking, the vigorous bushes making greater lengths of growth than the poor ones. The measurement is also a difficult matter.

In the case of the " 6 inches-to-janum," and " 6 inches-leaving-a-big-leaf " systems of plucking, each of which were repeated on four different sets of four lines, the following figures showing rather poor agreement were obtained.

Growth from bushes tipped at 6 inches.

Style of plucking.	Good bushes.		Poor bushes.	
	Central shoots.	Outside shoots.	Central shoots.	Outside shoots.
	ins.	ins.	ins.	ins.
6 inches to janum	11·0	9·5	9·9	9·0
	10·9	9·6	10·0	8·6
	11·0	9 7	8.9	8·2
	10·5	9·2	9 6	8 5
Average ...	10·9	9·5	9 6	8.6
6 inches, then 1 big leaf, then janum	12·8	11·0	12·0	10·6
	12 4	11 8	10 8	9·4
	13·1	11·3	11·3	10·2
	14 0	12·2	11·4	9·9
Average ...	13·1	11·6	11·4	10·0

(3) *Trial of Leaving Leaf while Maintaining Flat Bush.*

When a leaf is left on the second flush the surface of the bush becomes slightly convex; growth is more vigorous in the centre and there is a greater length of stalk between the first plucking mark and the new big leaf above it in the centre than

on the outside. Even near the centre, growth is not quite even so that pluckers when leaving a leaf take shoots from somewhat different levels, and the result is a somewhat uneven, and, in places, too empty plucking surface. The great advantage of plucking to a measure is the ease of accurate plucking once the plucking surface is established. A slight modification of the system of "leaving a leaf" was therefore tried. The initial length of 6 inches having been left and a flat surface established, a new measure of 8 inches from the pruning surface was issued, and plucking thereafter was at the 8-inch level. This had the effect of leaving much longer growth on the outsides so that early crop was lost. The resulting bush at the end of the season had a flatter, and more even, fuller surface, with stronger outsides, so that the loss made may probably be expected to be made up in later years.

The loss in crop was made between June 3rd and July 22nd when 116 lbs. leaf were taken by plucking to 6 inches and then to 8 inches, as against 138 lbs. from leaving a big leaf over 6 inches initial growth. During the remainder of the season crops were about the same.

(4) *Trial of Conical Plucking and Effect of Leaving Young Leaf on Bush.*

A trial of the old "conical" system of plucking was also made.

Supporters of such systems advance three main arguments in their favour :—

(*a*) A conical bush has a larger plucking surface than a *flat bush.*

(*b*) The centre shoots must grow more rapidly than the outsides, which latter are bound to grow weakly and can only yield well if plucked hard.

(*c*) The bush requires that young vigorous leaf shall be kept on it, if it is to remain vigorous.

With regard to (*a*) it is true that from the conical surface some shoots approximating to the horizontal are plucked : but since from the long growth left much fewer shoots arising from buds near the pruning cuts reach the surface, it is probably generally true that the conical surface has actually fewer plucking points than the closer-plucked flat surface.

(*b*) As far as the first few years are concerned the argument is correct; but if sides are left to grow they do eventually become strong. Bushes plucked flat for some years will carry very nearly as strong shoots on the outside as on the inside branches.

(*c*) The need for " young leaf " appears to vary very much with different bushes in different districts. It is a question very difficult to decide without many experiments in different districts and on different classes of tea.

The actual system tried was probably the commonest throughout tea about twenty years ago. Three big leaves are left when tipping, this commonly leaves about 6 inches in the centre and 3 inches or less on the outsides. Above that two big leaves were left leaving the centre about 10 inches or more, and the outsides about 4 inches. Above that one big leaf is left : subsequent plucking (from about the end of August) being to the janum.

In none of the experiments discussed here had it paid (in the first year) to leave any extra growth after the tipping, but it does not follow that this would be true for all districts and all types of bush.

To test this theory while still keeping a flat bush a trial was made of tipping at 4 inches, then when the sides had come up to the centre, raising the plucking a further 2 inches, and later a still further 2 inches. In Table IV the results of this system are compared with those from the conical plucking, and also with certain variations in flat plucking.

TABLE IV.

System of plucking.	LBS. LEAF PER 320 BUSHES.										Equal to mds. pucca tea per acre.
	Apl. 8 to Apl. 29.	May 6 to May 27.	June 3 to June 24.	July 1 to July 22.	July 29 to Aug. 19.	Aug. 26 to Sept. 16.	Sept. 23 to Oct. 14.	Oct. 21 to Nov. 11.	Nov. 18 to end of season.	Total for year.	
6", then janum	21	3	99	85	106	144	159	97	30	747	....
3 leaves, then 2 leaves, one leaf, then janum	41	2	104	45	120	142	118	107	24	703	....
4", then 6", then 8"	28	3	87	65	99	131	168	98	35	726	....
4", then 1 leaf, then janum	27	4	89	60	166	133	143	100	32	693	....
4", then janum	30	3	97	89	110	134	158	101	34	755	....
6", then 8"	19	2	60	56	97	132	154	101	30	650	....
8", then janum	14	3	97	82	100	140	159	101	36	733	....

Table IV gives first the results from plucking to 6 inches, taken as a standard flat plucking for comparison. It will be observed that over the whole season the "conical plucking" shown next in the Table makes about 6 per cent. less crop.

Because the conical plucking attacks the sides so severely the tipping in April yields very considerably more crop than is obtained when the sides are left till they come up to six inches. In June when some first flush was still being taken the conical plucking still yields the more. In July when practically only second flush was being taken there is naturally a considerable loss while waiting for two extra leaves to grow, but the bigger (and coarser) shoots taken above two leaves in the next four weeks give a larger weight of leaf than from the closer plucking. From September 23rd till October 14th, the conical plucking again loses leaf, for during this period many shoots still had to be left till the extra leaf grew. This period was again followed by a period of increased crop which might possibly have been maintained longer had the end of the season proved better climatically; but by this time the outsides were exhausted and *banjhi*, while the centre had grown tall thick shoots, too leafy to receive much stimulus to flushing. The crop after the middle of November was actually smaller than from any other plucking method tried.

At the end of the season the lines plucked by this method present a most ragged appearance. A few very poor bushes had grown no higher in the centre than about 8 inches above the pruning, while the most vigorous had grown 21 inches above the pruning. The average good bush had grown to about 17 inches above the pruning in the centre, sloping down to *banjhi* growth on the sides.

The curved surfaces also were not smooth, but irregular as different shoots grew at different rates. The system was found most difficult to follow accurately, and was very unpopular with the pluckers.

Plucking at 4 Inches, then 6 Inches, then 8 Inches.

These lines were plucked to a 4-inch measure till the end of May, after which 6-inch measures were used. From Table IV it will be observed that yields to the end of June were practically identical with those obtained from plucking at 4 inches and then leaving a big leaf on the second flush. Eight-inch measures were used from July 8th. It will be observed (from Table IV) that up to August 19th, there was little difference whether the bushes were plucked at 8 inches (after plucking at 4 inches and then 6 inches) or at approximately 6 inches (4 inches, then 1 big leaf). For the remainder of the season the bushes plucked 4 inches, 6 inches, 8 inches, yielded better than those on which one big leaf was left over 4 inches. The total gain was only about 4 per cent. and possibly may not be significant: but the result indicates a possibility that there may be conditions under which it pays to leave growth.

The next line in the table repeats (for easy comparison) the results from plucking at 4 inches to the janum. It will be observed that the general principle—that leaf is lost by leaving any growth above the original plucking level—still holds.

Two other results are repeated in Table IV for ease of comparison.

In these trials there are three systems of plucking by which the final height of the plucking table above the pruning is 8 inches before the use of a measure is abandoned.

These are—

1. 8 inches to janum	yield during season			733	lbs.
2. 6 inches, then 8 inches	,,	,,	,,	650	,,
3. 4 inches, then 6 inches, then 8 inches	,,	,,	,,	726	,,
For comparison:					
4 inches to janum	,,	,,	,,	755	,,

Up to the end of May while tipping, the yields vary, as expected, with the closeness of the plucking. (See Table IV.) In June and July both systems (2 and 3 above), under which

later growth is left, lose leaf as compared to the system under which the original plucking height is maintained (8 inches to janum). But system (2) loses much more than system (3) although the bushes have received only one check instead of two. It can only be surmised that the greater stimulus to vegetative growth from the earlier 4 inches plucking was persisting. From July 29th to August 19th all three systems yield alike: but from August 26th to October 14th the 4-6-8 system leads, after which all become roughly equal again.

Once a flat surface at the given height was established the measures were no longer used; but pluckers took all growth above the established level, leaving a small non-serrated (janum) leaf above the last plucking mark. There is always a certain length of stalk between the last plucking mark and the janam left, so that by the end of the season bushes have grown quite considerably above the original level fixed.

After plucking ceased, 12 bushes in each line were measured both in the centre of the bush and on the outside.

Six of the bushes were at the south end, where soil and bushes are particularly good, the other six bushes were at the north end, which falls on a strip of very poor soil.

The following were the results found :—

Length above pruning at end of season.

Plucking system.	South end where soil is good.		North end on strip of poor soil.	
	Centre of bush.	Outsides.	Centre of bush.	Outsides.
	ins.	ins.	ins.	ins.
6"—8"	12·7	11·6	11·9	10·9
4"—6"—8"	10·1	9·1	10·1	8·8
8" ...	11·9	10·4	10·2	9·0
6"	10·9	9·6	10·0	8·0

In the case of the 4 inches—6 inches—8 inches plucking, the time given between plucking at 6 inches, and plucking at 8 inches was insufficient to allow all shoots to be plucked at 6 inches before the plucking level was raised. Many outside shoots, of course, in all systems of flat plucking may be plucked very little, if at all, during the season, and are thus relatively spared. The system of attacking the stronger shoots first when they have reached only 4 inches, and again when they have reached only 6 inches, while shoots which have not reached the level are untouched, makes the differential character of flat plucking particularly marked, and consequently very level growth over the whole surface of the bush is obtained.

It will be observed that plucking at 4 inches—6 inches—8 inches on the good bushes left less growth at the end of the season than any system except plucking at 4 inches to the janam. It will be observed also that on the good bushes there is less difference between outside and inside than in the case of any other system of plucking; and that there is less difference between the good and the bad bushes than in the case of other plucking systems. When 8 inches was left originally, the good bushes grew distinctly more than after 4 inches—6 inches —8 inches plucking, when 6 inches—8 inches plucking was used the growth obtained was still greater. These differences may be presumed to mean greater distances between successive janams left, or more mistakes in plucking by which occasional big serrated leaves were left instead of janams only. In either case the greater growth would indicate greater vigour in the shoots, and certainly the general appearance of the bushes conveyed that impression.

Definition of "Janam" and of "Big Leaf" as used in these Experiments.

In carrying out experiments on plucking it is, of course, a matter of great practical difficulty to get work done accurately by pluckers. In these experiments the very closest supervision was exercised and it is believed that the number of shoots plucked incorrectly was small.

A greater difficulty arises over definitions. The final length of growth made on those lines which were plucked to the janam, was often commented on by planters. Men from districts where it is customary to leave long growth were inclined to be shocked at the closeness of plucking; while a few men from gardens which practise close plucking thought that the bushes had been rather allowed to run away, and pointed to a certain number of rather large "janams," which might almost be called "leaves."

"Janam" is an Assamese word meaning "birth," and the "janam leaf" means the first leaf on a new shoot arising from the axil of a leaf.

The first leaf on a new shoot is usually so small that it is only a bract at the base of the new stem: it is followed by one (or sometimes more) small non-serrated leaves, which are more oval than the succeeding large, pointed, serrated leaves.

In these experiments when a big leaf was ordered to be left, pluckers were instructed to leave the first serrated leaf. When only a janam was to be left they were instructed to leave the non-serrated leaf nearest to the point of origin of the shoot they were plucking. As the first bract-like janam often falls off by the time the shoot is ready for plucking, or is so shrivelled, or so small as to escape notice, it very often happened that the "janam" left was the second rather large janam, called in Assam the "gol pat" (round leaf). In these experiments, therefore, more growth was allowed than on gardens where the first "eye" only is left, whether the janam leaf below it has fallen off or not.

Summary.

These experiments as yet provide no definite evidence on which opinions regarding the desirability of different plucking systems can be based. They show only the effects of different plucking in the first year, on this particular tea.

From first principles it would be expected that the more a bush is denuded of leaf, the more are flushes forced from it. The danger lies in the possibility of forcing beyond the capacity of the bush, but the effect of such forcing would probably not show up in the first year.

These experiments have yielded the unexpected result that it made remarkably small difference to crop whether plucking was started at 4 inches, 6 inches, or 8 inches, but above that height the bushes went *banjhi* and took some time to come through, meanwhile losing crop. It is believed that poorer bushes would have gone *banjhi* at lower levels and lost crop if plucked at 8 inches instead of 6 inches.

To leave a big leaf after tipping caused a distinct loss of crop approximating to 10 per cent. Observation after one year only cannot be of great value, but the guess is hazarded that a poor bush is more spared by plucking at such a height that it first goes *banjhi*, than by forcing growth by early tipping, even if a big leaf is left afterwards. It is suggested that when a section requires sparing, it would be better to spare it by leaving long initial growth, than by leaving afterwards; because the poor bushes would be more strengthened, while the good bushes would still yield a full crop. If a section is spared by leaving leaf after short initial growth the expectation is that crop would be lost from the good bushes, while the poorer bushes would not benefit so much.

In all cases leaf was lost by leaving big leave after tipping. The old system of leaving the same number of leaves all over the bush to produce a conical surface, lost crop by 6 per cent. compared to plucking flat at 6 inches, and was found most difficult to deal with in the field.

The variation in the crops obtained in different parts of the season, indicate interesting possibilities of adjusting plucking systems to produce maximum crop at seasons when it is most convenient to pluck it.

THE CACHAR DISTRICT.

Soil Survey.

BY

C. R. HARLER.

Geography and Geology.

The Cachar district consists of the three sub-divisions of North Cachar, Silchar and Hailakandi. Practically the whole of North Cachar is hilly country whilst the other two subdivisions are classed as plains. The Cachar tea gardens are all situated in the plains.

To the north, the Cachar tea district is bounded by the North Cachar Hills which are part of the Barail Range running from the Garo Hills to the head of the Brahmaputra Valley. The outlying spurs of this range are the sites of many tea gardens. The Bhuban Hills, a continuation of the Lushai system, form the eastern boundary. The Rengti Hills forming the southern boundary, also project from the Lushai system and are separated from the Bhubans by the broad valley of the Rukni and Sonai. These hills generally run northwards into the district and, with the Chhatachura range to the west, form the Hailakandi Valley. The Chhatchura Range forms the western boundary of the district and divides it from the Chargola Valley of Sylhet.

To the north of the tea district of Cachar, steep hills make tea planting impracticable. To the south, the tea areas usually extend as far as the Inner Line Forest Reserve.

Teelas or hillocks, which characterise the Surma Valley, are dotted over almost every portion of the plains of Cachar, except in the valley of the Sonai.

References: Assam District Gazetteers, Vol. I—Cachar.
Records Geological Survey of India, Vol. XXXI, pt. 4.
The Petroleum Occurrences of Assam and Bengal by E. H. Pascoe, Mem. Geol. Surv. India, Vol. XL, pt. 2.
Mem. Geol. Surv. India, Vol. I, pt. 2.
" " " " Vol. XIX, pt. 1.
" " " " Vol. XL, pt. 2.

The chief river is the Barak which rises in Manipur, and after completely changing its direction several times, eventually enters the plains and then follows a tortuous course through the centre of the district till it reaches Sylhet at Badarpur. In the cold weather, the Barak flows in a deep bed with banks rising 40 to 50 feet on either side. In the Monsoon, however, the river frequently overflows and floods the surrounding country.

On its north bank in Cachar the Barak receives the Jiri, Chiri, Madhura and the Jetinga as main tributaries from the North Cachar Hills. From the Lushai Hills in the south, flow the Sonai, the Dhaleswari and the Khatakhal.

Some account of the part these rivers play in the land-making process which is steadily going on, may be of interest. The Barak enters Cachar from the east, a considerable stream over-charged with silt. As soon as the rains set in, the Chatla and Hailakandi valleys turn into swamps (*bheels*) which discharge into the Barak. As this river, however, receives its freshets from the north and east it eventually rises above the level of the two valleys and pours its own floods into them, and a thick muddy current, heavy with silt, passes into the valleys and swells the *bheels* into wide lakes. When the big river subsides the streams again turn from the *bheel* to the Barak, having left behind a deposit of silt. With innumerable repetitions of this process, the bottom of the district is raised, and lakes turn into fens, fens shallow into reedy swamps, swamps into grassy praries. Every stage in the process may be witnessed in Chatla Bheel.

What has been going on in the large scale described has also gone on in many small flats now planted out with tea. Water has quietly backed up between the hillocks and deposited silt and clay but, in addition, the wash from the surrounding *teelas* has left further deposits.

The hills surrounding the Cachar district are sandstones of the Tertiary period. The spurs which run into the valley are

Tipam sandstones of the Pliocene age and, geologically speaking, very young rocks. The alluvium of the plains is derived almost wholly from the Tipam sandstones.

The core of the Khasia and Jaintia Hills, which adjoin the North Cachar Hills, is gneissic rocks of the Archean geological era, and the same age as the ancient rock forming peninsular India. During the successive upheavals and subsidences of this part of India and the frequent deposit of sediment during flooding, the original gneiss of the Shillong Plateau has become overlain with sandstones and conglomerates of the cretaceous age, which contain occasional coal seams. These, in turn, are overlain by beds of the Tertiary period, consisting of limestone and sandstone with interstratified shales and coal deposits.

The more recent deposits of the Tertiary period form the mass of the Barail Range in which is included the North Cachar Hills, although this section of the Range has not the ancient core of the Khasia and Jaintia Hills. These latter Hills have not been subject to such violent disturbances as the rest of the Range, and the sedimentary deposits are horizontal, and are clearly displayed at Cherrapunji. At Gujong, in the Mahur Valley a few miles to the west of the hill section of the Assam Bengal Railway, these recent deposits are still horizontal, or nearly so. In the valley of the Mahur the change from the generally undisturbed condition of the newer rocks on the Shillong plateau begins, whilst at Guilong, on the east side of the Mahur Valley, the strata are almost vertical. For a great part of the hill section the railway runs along the fault constituting the geological boundary between the Khasia and Jaintia Hills and the rest of the Barail Range. This fact accounts for much of the trouble arising from the subsidence of tunnels and cuttings on this section of the railway.

Cachar, like the rest of Assam, is a siesmic area. The most notable earthquake on record in Cachar occurred in 1869 which was attributed to a fissure about 20 miles long, situated at a considerable depth below the surface of the northern border

of the Jaintia Hills. Cachar escaped with little damage from the earthquake in 1897.

Cachar is in the oil belt running from Assam to the Arakan, through Cachar and Chittagong. The petroliferous beds occur in a series of Tertiary rocks known as the "coal measures" which are supposed to form domes or anticlines cropping out beneath the newer sandstones and sometimes faulted against the older Disang shale series on the east.

The Tea Areas.

Tea was discovered wild in Cachar in 1855. South of the Barak, Lushai or Cachar indigenous tea, which is a variety distinct from that of Assam proper, is found.

The first tea in Cachar was planted in 1856 in Mauza Barsangan on the low spurs running from the Barail Range to the Barak. The *teelas* south of the Barak were then planted, and in 1875 the first *bheels* were drained and opened out. In 1869, there were 24,151 acres under tea in Cachar yielding somewhat over 170 lbs. per acre. By 1882 the area had risen to 48,873 acres with an outturn of about 260 lbs. per acre. By 1898 the area planted was 62,179 acres yielding about 340 lbs. per acre.

The Cachar tea district is divided into six sub-districts of the Indian Tea Association, consisting of North-West Cachar, North Cachar, Happy Valley, Lakhipur, Chatla Bheel and Hailakandi. The area under tea is, at present, 55,685 acres yielding about 510 lbs. per acre.

The price of Cachar tea is about 4*d*. per pound less than that of the Assam Valley. This defect is due partly to the climate but principally to Cachar methods both in the field and factory. The plucking is generally coarse and long, and the subsequent care and treatment of the leaf during manufacture is usually far from ideal. It must be mentioned, however, that it is economically sound to make cheap, poor tea in Cachar, not only on account of lower costs but also because there is a

very definite demand for such a commodity. With the adoption of fine plucking and careful manufacture, Cachar gardens, other than *bheel* gardens, could be made to produce teas almost equal in quality to the Assam average.

Climate.

The climate of Cachar is more difficult for tea than that of Assam on account of higher temperatures and lower humidities during the dry season, especially to the south of the district. In the early part of the year, scorching winds occur which sometimes wither the bushes. In the rains, the topography of the country makes for heat and humidity, and, at this time, the tea grows and flushes with a vigour not seen in the Assam Valley.

The average maximum temperature at Silchar, which may be taken as indicative of that of the tea district, is 78°F. in January and 90°F. in July. The January value is 8°F. above that of Sibsagar, but the July values are the same in both places. The minima in January and July are 52°F. and 77°F. respectively. Here again the July figure is the same as that in Sibsagar, but the January value is 3°F. higher.

The rains break earlier in Cachar than in Assam and are considerably heavier. The benefit from this extra precipitation is reduced by higher temperatures and lower humidities in the dry season in the Surma Valley than in the Assam Valley.

The average monthly rainfall at Silchar and Tocklai is shown below, in inches.

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Silchar	0·75	2·18	7·53	13,96	15·19	20·75	20·35	19·00	14·39	6·55	1·43	0·45	122·53
Tocklai	1·00	1·56	3·62	8·09	9·16	12 90	16·72	13·30	14·79	4·61	0·90	0·33	82·98

The Monsoon current blows into the Surma Valley from the south-west and then crosses the Hills to Assam where it augments the main current in the latter valley, which comes along the Brahmaputra. From East Bengal and South Sylhet, through Cachar to the North Cachar Hills there is a general

increase in rainfall followed by a decrease along the line of progress into Assam. As soon as the Brahmaputra Valley is reached and the rain shadow of the Mikir Hills left, the precipitation again increases on account of the rain brought by the main Monsoon current. The following total annual rainfall averages illustrate these points :—

Chandpur ...	Annual average rainfall ...	89 inches.
Habiganj ...	,, ,, ,, ...	99 ,,
Hailakandi	,, ,, ,, ...	114 ,,
Badarpur	,, ,, ,, ...	138 ,,
Bikrampore	,, ,, ,, ...	164 ,,
Nimotha	,, ,, ,, ...	203 ,,
Mahur	,, ,, ,, ...	76 ,,
Lumding	,, ,, ,, ...	50 ,,
Golaghat	,, ,, ,, ...	78 ,,
Sibsagar	,, ,, ,, ...	96 ,,
Dibrugarh	,, ,, ,, ...	112 ,,

Mahur is on the other side of the rain divide from Nimotha, and in the leeway of the hills.

Cachar Soil Types.

For practical purposes the Cachar tea areas are denoted as *teela*, plateau, *bheel* or flat and according to this division planting and general treatment varies. From the point of view of mechanical analysis the soils fall into two broad groups, the first of weathered soils of the *teelas*, and the second of soils washed from the *teelas*.

The *teelas* are generally sandy and have usually weathered considerably and, on this account, the clay fraction tends to become greater than the fine silt. The common *teela* type in Cachar is one in which fine sand is the greatest fraction, followed by coarse sand.

Nodular pans are common on *teelas* and, in some cases, a pan of such solidity occurs that planting is impossible. These pans are of chemical origin and consist largely of iron stone.

The nomenclature of soils adopted by this Department consists in a string of five numbers denoting the various fractions, placed in the order of magnitude of the fractions. Coarse sand is denoted by no. 1, fine sand by no. 2, silt by no. 3, fine silt by no. 4 and clay by no. 5. The soil analysis below, representing the commonest *teela* type, illustrates the use of this nomenclature.

Fraction.		Fraction number.
Coarse sand	25 %	1
Fine sand	45 %	2
Silt	15 %	3
Fine silt	5 %	4
Clay	10 %	5

Soil type ... 2, 1, 3, 5, 4.

An approximate idea of the soil texture is obtained from the soil type alone, although the limitations of such a nomenclature are apparent. Thus the type 2, 1, 3, 5, 4, might represent a sand, as above, or a stiff soil in which all the fractions are present in almost equal quantity.

In soils which have weathered far, the clay fraction is generally greater than the fine silt and the order—5, 4 of these two fractions, in a sandy soil, usually denotes a soil formed *in situ*. In a stiff soil where the 5 and 4 fractions are major ones, the same order may also denote a weathered soil, but not necessarily, for by sedimentation it is possible to deposit fractions in the order 5, 4, 3, 2, 1. It is however impossible for running water to deposit a mixture of particles represented by 1, 5, 4, 3, 2, or 1, 2, 5, 4, 3, or 1, 2, 3, 5, 4, in which the coarser fractions are major ones to the—5, 4 combination. The subject of sedementation and soil formation is more fully discussed in *Quarterly Journal*, 1924, pt. 3, p. 134.

The extremely light sandy *teela*, common in Sylhet, is rare in Cachar. So far as the available analyses go it only occurs at Heroncherra (Ballacherra) and Majagram, north of the Barak although it is more common to the south of the river.

Many of the lightest *teela* areas north of the river have been abandoned. A typical light sandy *teela* analysis is shown below.

Fraction.	Fraction	number.
Coarse sand	40 %	1
Fine sand	32 %	2
Silt	7 %	3
Fine silt	5 %	4
Clay	11 %	5
Soil type ...	1, 2, 5, 3, 4.	

The second general division of Cachar soils includes the plateau soils, occuring mainly in the Happy Valley and Lakhipur north of the Surma. This type, however, is sometimes met south of the Surma where the areas are generally described as *teelas*. The plateau soils are much heavier than *teela* soils and appear to have been washed from the latter and subsequently raised or left as a plateau by subsidence of the surrounding areas.

When soil is washed from a hill, every conceivable mixture may accumulate at the bottom, according to the slope of the hill, the amount of the wash and the slope of the flat at the bottom of the hill. What has usually happened with the wash from the Cachar *teelas* is that most of the coarse sand has accumulated at the bottom of the *teela* and the other fractions have been carried on to form the soil of the flat. The result is that, on most flats, coarse sand is relegated from the position of a major fraction to a place usually at the end of the soil type chain. The finer fractions, silt, fine silt and clay, are proportionately increased and the fine sand has often only retained its original proportion, and not increased as the silts and clay, owing to the fact that some of this fraction remains behind with the coarse sand.

Two types of plateau soil are given, one from Burtoll, which fits in with what might be expected, and one from Koomber which is rarer and a type difficult to explain from considera-

tions of sedimentation and weathering, on account of the shortage of fine silt.

Fraction.	Fraction no.	Plateau soils.	
		Burtoll.	Koomber.
Coarse sand	1	11	7
Fine sand	2	17	15
Silt	3	24	27
Fine silt	4	14	4
Clay	5	25	38
	Soil type ...	5,3,2,4,1	5,3,2,1,4

The Burtoll sample might well come from a flat. Here both coarse and fine sand cease to be major fractions, and from the light, sandy original soil, a heavy type of loam is formed. The Koomber sample is quoted because of the curiously low fine silt fraction. Similar types, though with a larger silt fraction, occur elsewhere in Cachar.

The remarks on plateau soils generally apply equally to flat soils. In some cases, however, usually in narrow *kunchis*, the *teela* soil appears to have slipped *en bloc* into the valley and, owing to the very gentle slope of the latter, little subsequent sorting of the particles has occurred. In such cases, the flat soil gives an analysis practically the same as the original *teela*.

In some instances the water from flats has been unable to get away and a bog or *bheel* is formed, which, on draining, grows vigorous tea. The mechanical analyses of *bheels* resembles those of flats, but the organic matter content is very much higher.

In picturing the formation of flats, the issue is sometimes complicated by the fact that muddy rivers may have backed up the valley and deposited silts which become incorporated with the washed *teela* soil. In such cases, irregularities occur which cannot be explained by considerations of straight forward sedimentation or weathering.

The wide variation of flat soils makes it difficult to give typical examples. Usually flats contain at least three consecutive fractions in about equal quantities and are of the general types 1, 2, 3, or 2, 3, 4 or 3, 4, 5. The following are frequently met.

Fraction.	Fraction no.	Clay flat.	Medium flat.
Coarse sand	1	5	6
Fine sand	2	7	29
Silt	3	17	26
Fine silt	4	29	24
Clay	5	32	8
	Soil type	5,4,3,2,1	2,3,4,5,1

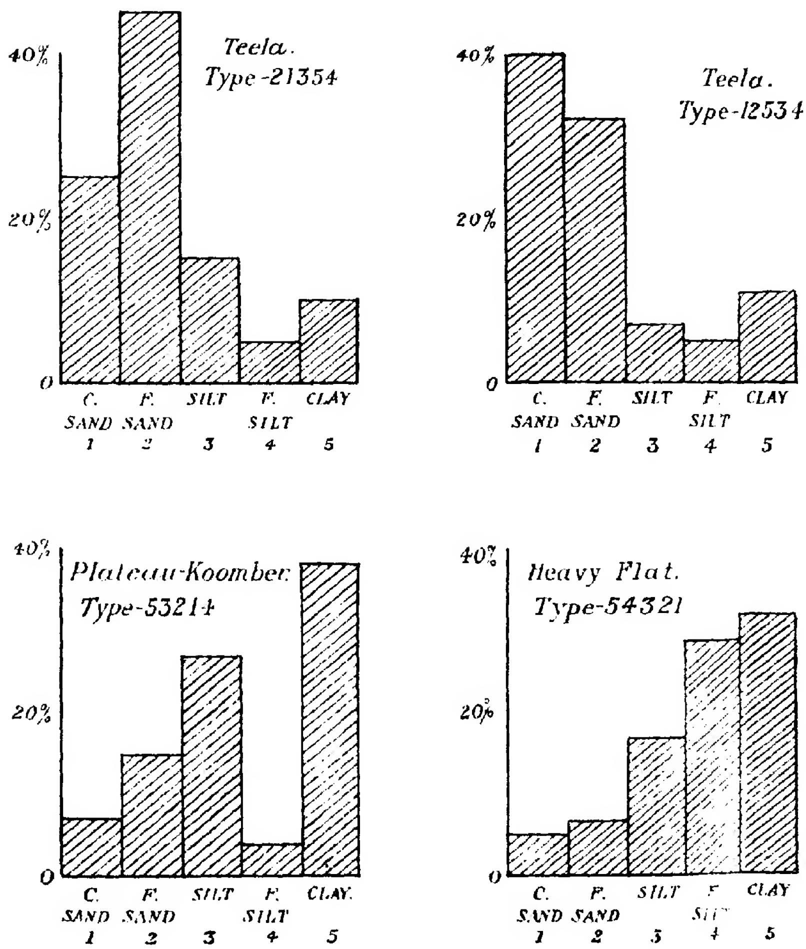
The commoner soil types met in Cachar are graphically represented opposite.

It is now necessary to consider the full analyses of some typical soils. The table below gives the mechanical and chemical analyses of a *teela* soil from Ballacherra, a plateau soil from Burtoll, a light sandy flat from Chandypore, a stiff flat from Lallamukh and a *bheel* from Derby.

TYPICAL CACHAR TEA SOILS.

	Teela, Ballacherra.	Plateau, Burtoll.	Sandy flat, Chandypore.	Clay flat, Lallamukh.	*Bheel*, Derby.
	%	%	%	%	%
Mechanical Analysis—					
Coarse sand	25·3	12·9	5·0	16·4	23·5
Fine sand	38·6	30·8	43·4	14·0	7·5
Silt	15·2	26·6	23·3	17·9	8·2
Fine Silt	5·9	8·8	11·7	22·1	11·1
Clay	10·1	15·2	11·2	19·4	12·9
Loss on ignition	3·51	5·05	4·60	9·32	35·12
Soil Type	2,1,3,5,4	2,3,5,1,4	2,3,4,5,1	4,5,3,1,2	1,5,4,3,2
Chemical Analysis—					
Organic matter (Grandeau)	1·37	1·63	1·32	3·34	29·86
Insoluble silicious matter	88·42	84·40	86·96	74·45	54·80
Acidity (Hopkins)	1371	993	1439	4201	4785
Nitrogen	0·119	0·125	0·119	0·205	0·581
Available phosphoric acid	0·011	0·027	0·12	0·029	0·062
" potash	0·008	0·005	0·008	0·008	0·028
" lime	0·039	0·019	0·055	0·020	0·018

SOME CACHAR SOIL TY.



The loss on ignition is some measure of the total organic matter in the soil, whilst the organic matter estimated by the Grandeau method may be taken as an indication of the degree of rotting of the organic matter. The insoluble silicious matter is largely quartz and indicates inactive mineral matter not entering the soil solution. This value is usually highest in the sandiest soils. The available potash, phosphoric acid and lime must be considered in relation to the amount of insoluble, non-silicious matter for, the smaller this quantity, the lighter the soil usually, and consequently the greater the root range of the bush. The result is that soluble quantities of plant food indicating a poor soil in the case of a clay, may indicate a very good soil in the case of a sand.

The acidity values are those estimated by the Hopkins method, the full interpretation of which is difficult and it is impossible to denote any figure as a safe acidity value. Other acidity constants, the pH value of the soil solution and the pH value of the nitrate of potash extract, are of more use and generally distinguish between good and bad tea soils. The determination of these constants is, at present, not included in a soil analysis made by the Calcutta analysts. Many of these estimations are, however, made at Tocklai and, in the case of a soil showing a very low or very high Hopkins acidity, we prefer to make pH determinations before suggesting manurial treatment.

The term *bheel* is taken, locally, to denote a flat rich in organic matter but, in its general sense, a *bheel* area is a drained fen or bog. The peat *bheels* after some years often deteriorate either by sinking below the drainage level or by being overdrained. In the latter case, alternate seasonal wetting and drying eventually robs the colloidal matter in the soil of its stickiness, and the *bheel* becomes " fluffy " and difficult to wet.

When a rich flat deteriorates for reasons not connected with drainage, a loss of organic matter and nitrogen is generally observed. Liberal manuring is the only remedy.

When a coarse sandy *bheel* deteriorates it does not go " fluffy " but usually dries out and the tea suffers during the dry season. These deteriorated soils are often characterised by a high phosphoric acid and low potash content and high acidity. Such areas are usually liable to severe mosquito attack, probably on account of the drought effect but possibly also by reason of the deficiency in potash. The judicious application of potash manures in such cases may increase the resistance of the bush to mosquito attack.

When *teelas* are top dressed with *bheel* soil the first results are beneficial. After a time, however, the organic matter and nitrogen in the soil are partially dissipated and the tea begins to deteriorate. *Teela* soils, on top dressing, show a very great increase in soil acidity, the value rising from about 1,000 to 4,000 or 5,000. As the area deteriorates the acidity does not appear to change and on such areas the application of lime in small doses should do good.

The Manurial Treatment of Cachar soils.

In considering the manurial treatment of Cachar soils or, in fact, of practically any tea soil in North-East India, it may be assumed that the addition of nitrogenous manures will increase the crop. The only definite experiment made on a peat *bheel* showed that this also responded to additions of nitrogen, although it is usually stated that *bheels*, rich in peat, do not require manuring.

The nitrogenous manures now on the Calcutta market include sulphate of ammonia, nitrate of soda, nitrate of potash, calcium cyanamide, animal meal, cake and blood meal. The last three manures are of an organic nature and expensive. Of the others, sulphate of ammonia and calcium cyanamide are cheap and have been proved to give good returns. In most cases the use of one or the other of these manures is suggested.

With the high temperatures and humidities ruling in North-East India the dissipation of organic matter from the soil is rapid, especially where the bushes are not big enough to

protect it from the direct rays of the sun. In such areas, the addition of organic matter in bulk, either as cattle manure or green crop, is essential. On areas where the tea is touching, the leaves shed from the bush supply much organic matter, but the addition of further supplies in the form of Boga medeloa is advisable in many cases. Well shaded areas of fully grown tea can be left without green crops if labour is short. When an area is cut back the opportunity of growing as many green crops as possible should be taken.

Any manurial cycle, then, must include frequent doses of nitrogen with green crops or cattle manure as often as possible.

In considering the potash and phosphoric acid requirements of our tea soils, experience has shown that the heavier soils need more phosphoric acid than the lighter ones and the lighter soils need more potash than the heavy ones.

Another factor for consideration in applying manures is the soil reaction. Tea does best on soils showing an acidity of about pH = 5.4. The continued application of acid manures like sulphate of ammonia to soils already strongly acid is not good. On the other hand the continued application of alkaline manures like calcium cyanamide to soils of a slightly acid nature is to be avoided. The careful use of acid and alkaline manures should keep the soil reaction at a suitable figure.

Another point to consider is the manurial treatment of green crops. These thrive on phosphatic manures and on lime. Hence, at the time of sowing, a dose of phosphoric acid should be given. Tea itself does not usually require lime, but, calcium cyanamide when it decomposes yields somewhat more than its own weight of limestone. It follows then, that, in a manure cycle, this fertilizer may, with advantage, be added the year before green cropping. If it be added the year of green cropping, the application should be made well ahead of the sowing of the green crop, because this manure is liable to kill seedlings when it is first applied.

Bearing these principles in mind, a manurial programme may be constructed. Four cases are considered below, two for clays and two for sands. A soil containing above 10 per cent. clay may generally be treated as a clay although the percentages of the other fractions should also be taken into account. For both types of soil two programmes are given, one for areas where ground green crops like cowpeas or dhaincha can be grown and one where the tea is too big to allow of such growth.

The rates refer to applications per acre. The manures should be broadcast except in cases where the root area is so limited that much of the manure may be lost to the bush by this method of application. In these cases the manure should be forked round the bush.

The applications, except in the case of calcium cyanamide, are usually made in April. Cattle manure may be applied whenever labour is available.

CLAY SOILS.

	With ground green crops.	*Without ground green crops.*
A.	Calcium cyanamide, 2 cwt. per acre, Feb. or March.	Same as opposite.
B.	Alphos, 2 cwt. per acre, broadcast up lines before sowing ground green crops *or* cattle manure, 5 tons per acre.	Cattle manure, 5 tons per acre or Oilcake, 8 mds. per acre *or* Sulphate of ammonia, 2 cwts. Muriate of potash, ½ cwt. Superphosphate, 1½ cwts. per acre in March or April.
C.	Sulphate of ammonia, 2 cwts. Muriate of potash, ½ cwt. Superphosphate, 1½ cwts. in March or April.	Same as opposite.
D.	Boga medeloa in every third row. Lop fre-	

quently and thin out to clumps at end of season, *or* Rahar in alternate rows, lop frequently. Bury at end of season.	Same as opposite.
Calcium cyanamide 2 cwts. per acre in February.	
E. Sulphate of ammonia, 2 cwts. Muriate of potash, ½ cwt. Superphosphate, 1½ cwts. in March or April.	Same as opposite.

SANDY SOILS.

With ground green crops.	*Without ground green crops.*
A. Sulphate of ammonia, 2 cwts. Sulphate of potash, ½ cwt. in March or April.	Same as opposite.
B. Alphos, 1½ cwt. per acre broadcast up lines before sowing ground green crops *or* Cattle manure, 5 tons per acre.	Cattle manure, 5 tons per acre *or* Oilcake, 2 mds. per acre. *or* Sulphate of ammonia, 2 cwts. Sulphate of potash, ½ cwt. Superphosphate, 1½ cwts. in March or April.
C. Sulphate of ammonia, 2 cwts. Sulphate of potash, ½ cwt. in March or April.	Same as opposite.

D. Boga medeloa in every third row. Lop frequently and thin out to clumps at end of season *or* Rahar in alternate rows. Bury at end of season.	Same as opposite.
Sulphate of ammonia, 2 cwts. Sulphate of potash, ½ cwt. Superphosphate, 1½ cwts. in March or April.	
E. Calcium cyanamide, 2 cwts. in February. Bury Boga medeloa at end of season.	Same as opposite.

The cost of these programme works out at about Rs. 19 per acre, per annum, for the Calcutta purchases, excluding cost of seed for green crops or freight and application of mixtures. This is the minimum expenditure advised. The careful carrying out of such a programme will give an increase at the end of five years of at least 25 per cent. above what the area would have been giving if it had been left unmanured. This does not indicate that the crop will necessarily increase above its present value to that extent. The general tendency with fully developed tea is for the crop to fall off gradually and, if the rate of decrease is a cumulative 5 per cent. per annum, a manuring cycle may only keep pace with this and the crop will remain stationary.

For the detailed use of a manuring cycle reference should be made to the *Quarterly Journal,* Part II, 1924, and for suggestions on the treatment of *bheels* the reader is referred to the *Quarterly Journal;* Part IV, 1922, p. 152.

It is not suggested that the manure cycles outlined above should be taken as they stand and applied to any garden, for

there are minor conditions on most areas requiring some modification of the broad principles. These modifications can be learned by application to Tocklai.

Below is given, as an appendix, the mechanical analyses of soils from the various Cachar gardens. In many cases all the available analyses are given, but in others, where samples from similar areas have been taken, only typical analyses are quoted. The figures are percentages, given in the case of the soil fraction to the nearest unit. Partly on this account and also because the matter soluble in dilute acid is omitted, the percentages often add up to something less than 100.

ANALYSES OF CACHAR SOILS.

North-West and North Cachar.

Jellalpur, the most westerly of the Cachar gardens, shows three type of sandy loams.

Soil mark.	Coarse sand.	Fine sand	Silt	Fine silt.	Clay.	Loss on ign.	Soil type.
Jellalpur No. 1	21	29	9	15	21	5·23	2, 5, 1, 4, 3
,, No. 2	20	21	15	16	22	5·45	5, 2, 1, 4, 3
,,	27	28	10	19	12	3·49	2, 1, 4, 5, 3

At Kallinecherra the samples are variations of heavy and light silts and of interest because the silt fraction (no. 3) seldom occurs as a major fraction in the tea soils in North-East India.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Kallinecherra							
No. 4 Dhip	16	17	42	12	9	3·55	3, 2, 1, 4, 5
,, No. 2 Kch.	4	23	23	26	18	5·39	4, 2, 3, 5, 1
,, No. 3 Kch.	5	22	31	16	4	5·55	3, 2, 4, 1, 5

Silts, especially clay silts like no. 2 above, are difficult to work and are only kept friable by the addition of bulky organic matter.

At Craigpark occur soils formed by weathering and also deposited by water in some geologically recent time. The

weathered soils are represented by the first two, in which the clay and fine silt fractions occur in the order—5, 4, and—5, 1, 4. The second sample is a much richer soil than the first.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay	Loss on ign.	Soil type.
Craigpark No. 8	6	34	36	7	13	4·36	3, 2, 5, 4, 1
" No. 3 Ballicherra	16	26	25	5	19	7·95	2, 3, 5, 1, 4
" A.	11	52	21	10	6	3·38	2, 3, 1, 4, 5
" B.	21	45	14	17	4	2·48	2, 1, 4, 3, 5
" C.	13	44	30	9	4	3·93	2, 3, 1, 4, 5

At Kalline, all the samples except the last are of the stiff, silt-clay type. The last sample is of the—2, 4 type with fine sand and silt as major fractions. Soils of this type are usually hard and " steely " in the cold weather.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Kalline, Anush No. 4	2	23	30	21	18	4·70	3, 2, 4, 5, 1
" No. 9	1	3	20	39	28	6·07	4, 5, 3, 2, 1
" No. 10	9	18	16	21	26	7·83	5, 4, 2, 3, 1
" No. 13	3	14	33	22	20	5·49	3, 4, 5, 2, 1
"	9	28	18	26	15	4·14	2, 4, 3, 5, 1

At Kurkoorie several very distinct types occur, from light sands to stiff clays, with intermediate loams.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay	Loss on ign.	Soil type.
Kurkoorie	8	61	16	8	4	2·22	2, 3, 4, 1, 5
"	14	43	18	12	10	4·23	2, 3, 1, 4, 5
"	19	30	17	11	17	6·33	2, 1, 3, 5, 4
"	1	9	26	38	19	5·81	4, 3, 5, 2, 1
"	5	42	25	15	10	4·02	2, 3, 4, 5, 1

The second and third samples are physically the best, containing, as they do, good proportions of fine and coarse particles, the former for food supply and the latter to keep the soil open and tractable.

At Bikrampore occur both the sandy type usually met on *teelas* and the heavy flat type. The description of the soils, however, given on the analysis forms, does not indicate the nature of the area.

It may be mentioned here that, at Tocklai, a full description of an area is appreciated when we are devising manure programmes, and soil samples marked alphabetically or numerically are not so helpful as a descriptive marking indicating the section number and the nature of the area, whether *teela,* flat or *bheel*. In most cases, insufficient marking of soil samples makes it necessary for us to guess at the probable nature of the area.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Bikrampore ...	2	19	29	27	17	4·90	3, 4, 2, 5, 1
,, ...	30	39	10	11	7	2·41	2, 1, 4, 3, 5
,, ...	27	38	11	12	9	8·85	2, 1, 4, 3, 5
,, ...	20	38	14	15	9	3·34	2, 1, 4, 3, 5

Crossing into North Cachar, the first garden of which analyses are available is Ballacherra. Both the normal sandy *teela* and the heavier silt flat soils occur.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Ballacherra H. 22 ...	9	30	16	10	26	8·36	2, 5, 3, 4, 1
,, Khasia flat	*nil*	24	32	25	13	4·67	3, 4, 2, 5, 1
,, Office flat...	15	40	22	8	9	4·92	2, 3, 1, 5, 4
,, Oraon flat	8	29	32	12	11	5·05	3, 2, 4, 5, 1
,, Kasta flat...	2	14	41	15	9	7·41	3, 4, 2, 5, 1
Sonacherra No. 1 ...	6	37	30	12	20	3·58	2, 3, 5, 4, 1
Heroncherra H. 1 ...	25	21	21	7	17	6·71	1, 2, 3, 5, 4
Panicherra No. 1 .	25	39	15	6	10	3·51	2, 1, 3, 5, 4

All but the first, fourth and fifth soils are from flats. The *teela* soils all exhibit the—5, 4, grouping as does also the Ballacherra Office Flat sample although not in a marked degree.

Doloo is on the plateau stretching from this garden across to the extreme east of the Cachar district. The plateau soils

are usually heavier than the *teela* soils, and the probable formation of this area may account for this. Thus, it is likely that what is now plateau was washed from the North Cachar Hills to form a flat. Subsequent upheaval of this flat or subsidence or erosin of the lands to the south, formed a plateau. Frequently, near the plateau, true *teela* land is met and then the usual *teela* soil type occurs.

Plateau soils form the greater part of the high land in the Happy Valley and in the part of Lakhipur, north of the Surma. These soils often contain large rocks of sandstone and shale, with the interstices filled with the stiffish soil common to the plateau.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Doloo	15	26	25	11	15	6·38	2, 3, 5, 1, 4
Hatticherra ...	32	36	6	9	11	5·56	2, 1, 5, 4, 3
Rampore No. 2 ...	19	35	15	16	10	4·91	2, 1, 4, 3, 5
,, No. 3 ...	18	36	16	15	9	4·60	2, 1, 3, 4, 5
,, No. 4 ...	14	31	19	17	12	5·51	2, 3, 4, 1, 5
,, No. 5 ...	16	40	13	15	10	5·71	2, 1, 4, 3, 5
,, No. 6 ...	12	29	13	19	20	6·43	2, 5, 4, 3, 1

The Doloo sample exhibits the—5, 4, combination of a weathered soil but is heavier than the normal *teela*.

Khoreeal and Kallynugger are partly on the plateau and partly on *teela* and flat.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Khoreeal—Kopibari ...	5	23	39	12	15	5·16	3, 2, 5, 4, 1
,, No. 1 *teela* ...	6	23	38	8	15	6·76	3, 2, 5, 4, 1
,, Kallynugger	17	32	19	8	19	4·80	2, 3, 5, 1, 4
,, Kona *teela* ...	17	25	13	8	30	7·18	3, 2, 4, 5, 1
,, No. 9 flat ...	5	19	44	14	12	6·70	5, 2, 1, 3, 4
,, No. 9 Kallynugger ...	28	32	21	4	9	5·07	2, 1, 3, 5, 4

The Kopibari sample is a narrow flat between high *teelas* and probably consists of *teela* soil washed down and deposited *en bloc*. This sample is identical with No. 1 *teela*. The

Kallynugger and Kona *teela* samples are both described as plateau lands.

The Happy Valley District.

This sub-district consists of the Koomber plateau and the lines of teelas which extend to the Barak River. At Koomber itself the soils are heavy clays almost devoid of fine silt.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Koomber ...	7	15	27	4	38	8 96	5, 3, 2, 1, 4
„ ...	16	26	21	4	27	6 31	5, 2, 3, 1, 4
Teekulpar ...	*nil*	5	43	17	27	6·39	3, 5, 4, 2, 1
Burratoll No. 10 ...	21	34	10	16	13	4·60	2, 1, 4, 5, 3
Sunatallah ...	12	17	15	24	23	7·85	4, 5, 2, 3, 1
Kumbargram No. 3 ...	9	17	30	7	25	10·52	3, 5, 2, 1, 4

The Teekulpar sample also resembles the plateau type being too heavy for the average *teela* whilst the two samples following are of the type met on flats. The Koombergram samples resembles those of Koomber.

At both Pathemara and Pathecherra the soils are of the washed type.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Pathemara No. 2 ...	6	16	15	39	13	8·25	4, 2, 3, 5, 1
„ No. 15 ...	8	28	20	29	7	5·85	4, 2, 3, 1, 5
„ No. 24 ...	9	30	25	21	7	6·75	2, 3, 4, 1, 5
„ Augustnugger No. 1 ...	26	32	12	17	9	3·02	2, 1, 4, 3, 5
„ Siburband No. 13 ...	2	7	36	25	25	6·14	3, 5, 4, 2, 1

At Goabarrie, north of the plateau, and in the hills the soil is of the typical *teela* type 2, 1, 5, 4, 3.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Goabarrie China No. 2	18	39	10	13	14	4·73	2, 1, 5, 4, 3
„ No. 5 ...	23	37	6	13	16	4·30	2, 1, 5, 4, 3

From Cherrie Valley (Annacherra and Martycherra) the samples display the *teela*, the flat and the plateau type, the last denoted by a shortage in the fine silt fraction.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Annacherra ...	24	38	17	7	10	3·39	2, 1, 3, 5, 4
„ No. 18 ...	23	27	20	9	8	3·33	2, 1, 3, 4, 5
Martycherra No. 3 ...	16	20	22	6	28	5·75	5, 3, 2, 1, 4
„ No. 10 ...	17	21	25	15	14	5·77	3, 2, 1, 4, 5

The first sample from Annacherra is typical *teela*.

Since the flat and plateau types are similar it is difficult to say, definitely, whether a section is flat or plateau without local information. Thus at Endogram the only soil analysis available is of the flat type. At Thaligram, on the opposite side of the Koomber plateau, the soils are variations of the flat type, with the coarse sand as the smallest fraction. The sample, Thaligram no. 14, is described as *teela*, but its analysis suggests plateau land. Thaligram no. 1 also appears to be a washed soil in spite of its fair proportion of coarse sand. At Nagadoom several samples, very similar, all appear to be flats except the last sample which is a *teela* type.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Endogram ...	7	22	18	17	26	7·58	5, 2, 3, 4, 1
Thaligram B. 13 ...	1	18	16	36	22	5·46	4, 5, 2, 3, 1
„ D. 14 ...	2	34	20	20	17	4·94	2, 3, 4, 5, 1
„ No. 14 ...	4	26	17	22	23	6·00	2, 5, 4, 3, 1
„ No. 1 ...	10	38	12	19	14	5·30	2, 4, 5, 3, 1
Nagadoom No. 1 ...	8	29	19	21	18	4·16	2, 4, 3, 5, 1
„ No. 1 Tingtang ...	20	35	7	14	16	5·57	2, 1, 5, 4, 3

On the other side of the Madhura River, soil analyses from Chandighat and Larsingah are available. The Chandighat analyses show *teelas* of varying degrees of heaviness and flats. From Larsingah some of the samples resemble the Koomber soils in their shortage of fine silt. Some of the samples described as

teelas are representative of plateau soils. The samples below are typical of the large number of analyses available.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Chandighat ...	8	14	22	16	30	8·60	5, 3, 4, 2, 1
" ...	17	23	16	15	21	6·40	2, 5, 1, 3, 4
" ...	9	13	18	15	34	9·61	5, 3, 4, 2, 1
" ...	21	32	14	11	16	4·95	2, 1, 5, 3, 4
" ...	14	30	17	14	18	5·76	2, 5, 3, 1, 4
" ...	2	40	21	19	13	4·02	2, 3, 4, 5, 1
Larsingah ...	3	4	31	22	32	7·21	5, 3, 4, 2, 1
" Kookee *teela* No. 3 ...	11	23	26	9	25	6·15	3, 5, 2, 1, 4
" Kookee *teela* No. 6 ...	26	27	17	7	18	4·50	2, 1, 5, 3, 4
Chotasingah No. 12 ...	11	13	25	15	28	7·37	5, 3, 4, 2, 1
" Line *teela*	11	13	15	18	34	8·23	5, 4, 3, 2, 1
Barasingah flat No. 10	17	25	15	16	21	5·23	2, 5, 1, 4, 3
New Bhotan *teela* ...	11	16	17	15	31	7·74	5, 3, 2, 4, 1

To the south-west of the Koomber plateau runs a string of *teelas* among which Urrunaband, Doyapur, Chapannala, Majagram, Arkatipur and Cossipur are put out. The following analyses are available, indicating ordinary *teela* and flat.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Urrunaband ...	6	26	17	24	19	7·71	2, 4, 5, 3, 1
Doyapore No. 3 *bheel*	1	3	12	44	20	19·65	4, 5, 3, 2, 1
" 1911 *teela*	20	41	12	11	10	5·77	2, 1, 3, 4, 5
Majagram No. 7 *teela*	36	19	12	9	19	4·99	1, 5, 2, 3, 4
" No. 9 flat ...	11	23	31	10	17	7·25	3, 2, 5, 1, 4
Durgunugger No. 7 flat	18	19	26	10	14	11·76	3, 2, 1, 5, 4
" No. 2 "	10	9	11	28	14	25·57	4, 5, 3, 1, 2
" No. 5 "	8	6	26	23	21	14·87	3, 4, 5, 1, 2
Cossipore ...	1	4	18	35	32	7·92	4, 5, 3, 2, 1

The Lakhipur District.

The Lakhipur district is a large one, including part of the Koomber plateau and the area between the Labac and the Chiri Rivers and also the gardens south of the Surma bordering on the Bhuban range. Unfortunately few analyses are available.

The first convenient group of gardens to consider includes Scottpore, Doloogram, Budlicherra, Pallorbund and Narainpore,

since these start at the plateau and are included in the line of *teelas* and raised land which extends to the south.

Both the Scottpore samples are of *bheels,* albeit poor in organic matter, and, as such, show the analyses of flat areas. From Doloogram both *teela* and flat analyses are shown. The Budlicherra samples suggest flats.. The Narainpore soils are of the type formed by weathering, in which coarse and fine particles form major fractions.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Scottpore bheel No. 1...	8	42	18	19	8	5·30	2, 4, 3, 1, 5
" " No. 2...	3	44	16	21	10	5·13	2, 4, 3, 5, 1
Doloogram, Manipuri *teelas* ...	13	35	21	10	16	4·62	2, 3, 5, 1, 4
" Iringmara Narain flats	3	41	26	12	12	4·15	2, 3, 4, 5, 1
" Lattigram flat ...	12	31	22	11	16	6·02	2, 3, 5, 1, 4
" Pollarband *kunchi* ...	14	18	15	21	12	17·20	4, 2, 3, 1, 5
Budlicherra No. 19 ...	11	20	21	12	25	10·54	5, 3, 2, 4, 1
" No. 18 ...	11	16	20	14	31	7·57	5, 3, 2, 4, 1
Pollarband, Doloogram *kunchi* ...	33	39	11	9	4	2·46	2, 1, 3, 4, 5
" M. P. *kunchi*	20	43	12	13	7	5·42	2, 1, 4, 3, 5
" No. 6 flat...	36	22	9	16	9	6·26	1, 2, 4, 3, 5
" Singlo *kunchi* ...	28	31	11	15	7	6·48	2, 1, 4, 3, 5
Narainpore 1912 ...	16	12	8	18	22	23·23	5, 4, 1, 2, 3
" "18 acres"	18	29	16	16	17	4·45	2, 1, 5, 3, 4

As previously mentioned, plateau soil types seldom occur south of the Surma and the *teelas* and spurs coming from the North Cachar Hills are less sandy than those related to the Lushai Hills. The North Cachar Hills are generally richer in shales (laminated clays) than are the hills on the other side of the Surma and it is likely that, on this account, the plateau soils are more consistently heavy than flat soils washed from the *teelas* in the neighbourhood of the Lushai Hills.

Plateau soils frequently exhibit no. 5 (clay) and no. 2 or no. 3 (fine sand or silt) as major fractions. At both Burtoll and Dewan the general —5, 3, 2 type occur.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Burtoli 1 ...	11	17	24	14	25	7·17	5, 3, 2, 4, 1
„ 2 ...	16	15	24	14	24	7·52	3, 5, 1, 2, 4
„ Lyd. A ...	1	16	47	12	18	5 05	3, 5, 2, 4, 1
„ „ B ...	16	19	32	6	21	6 71	3, 5, 2, 1, 4
„ „ E ...	7	17	27	13	29	7·67	5, 3, 2, 4, 1
„ „ F ...	2	4	40	26	22	6·29	3, 4, 5, 2, 1
„ Bal. 1 ...	1	8	47	14	23	6·29	3, 5, 4, 2, 1
„ „ 2 ...	1	34	43	8	11	3 50	3, 2, 5, 4, 1
„ „ 3 ...	22	31	24	4	5	5 83	2, 3, 1, 5, 4
„ No. 5 J ...	13	31	27	9	15	5·05	2, 3, 5, 1, 4
„ No 6 B ...	13	21	27	6	26	5 66	3, 5, 2, 1, 4
„ No. 3 B .	15	29	31	5	13	5·35	3, 2, 1, 5, 4

At Labac the —5, 3 type does not occur.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Labac No. 7 flat ...	21	25	8	5	36	5·26	5, 2, 1, 3, 4
„ Naraiupore *bheel*	2	3	19	39	26	10·98	4, 5, 3, 2, 1
„ No. 15 flat ...	24	19	14	9	19	4 59	1, 2, 5, 3, 4
„ No. 8 *bheel* ...	1	4	7	33	42	12·15	5, 4, 3, 2, 1
„ No. 7 old ...	21	25	24	6	19	4·46	2, 3, 1, 5, 4
„ No. 12 flat ...	7	15	14	33	21	8·89	4, 5, 2, 3, 1
„ No. 12 *teela* ...	3	25	19	24	22	6·22	2, 4, 5, 3, 1
„ sandy flat ...	9	59	16	9	4	2·35	2, 3, 4, 1, 5

At Dewan there are, broadly speaking, two types, one the —2, 4, in which fine sand and fine silt are major fractions and the other of the —5, 3 or —2, 5, 3 type with the fine silt (grade 4) at the end of the chain. The second type resembles the Koomber plateau soils. The two types occur on all the divisions of Dewan.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine salt.	Clay.	Loss on ign.	Soil type
Lallong No. 2 ...	9	33	17	19	14	6·19	2, 4, 3, 5, 1
„ No. 7 ...	11	32	4	26	21	5·78	2, 4, 5, 1, 3
„ ...	18	22	21	8	22	6·68	2, 5, 3, 1, 4
Thailu No. 2 ...	6	23	24	25	14	7·52	4, 3, 2, 5, 1
„ No. 23 ..	9	30	17	21	15	7·53	2, 4, 3, 5, 1
„ ...	18	20	22	6	25	7·19	5, 3, 2, 1, 4
Bundoo No. 4 ...	7	23	20	26	17	8·27	4, 2, 3, 5, 1
„ ...	13	19	25	8	26	7·83	5, 3, 2, 1, 4
Dewan ...	17	22	25	11	20	6·15	3, 2, 5, 1, 4
„ No. 8 ...	10	33	19	17	15	6·02	2, 3, 4, 5, 1

The gardens south of the Surma may now be considered. At Binnakandi extreme types are met including very heavy clays and light sands.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Binnakandi Hattikuri	1	3	8	34	35	17·77	5, 4, 3, 2, 1
" plateau re-planted ...	25	39	12	11	10	3·52	2, 1, 3, 4, 5
" Gobindthal	17	59	9	8	4	2·5	2, 1, 3, 4, 5
" Hattikuri No. 3 ...	7	40	29	15	8	3·63	2, 3, 4, 5, 1
" Rungthal No. 1 ...	22	12	10	16	21	7·46	5, 1, 4, 2, 3
" Rungthal No. 1 ...	2	13	12	29	13	28·98	4, 2, 5, 3, 1

The remaining analyses of this area are as follows :—

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine slit.	Clay.	Loss on ign.	Soil type.
Tilkah No. 11 ..	4	19	20	34	16	6·77	4, 3, 2, 5, 1
" No. 93 ...	3	27	16	29	17	8·39	4, 2, 5, 3, 1
Bhubandhar ...	*nil*	27	26	23	15	7·36	2, 3, 4, 5, 1
" ...	*nil*	34	15	29	15	6·59	2, 4, 5, 3, 1
Bhuban Valley No. 6	1	8	20	35	25	9·85	4, 5, 3, 2, 1
" " No. 6	6	42	18	17	10	7·49	2, 3, 4, 5, 1
" " No. 3C.	7	55	14	12	6	4·72	2, 3, 4, 1, 5
" " No. 6 C.E.M.	12	51	12	15	15	5·60	2, 4, 5, 3, 1
" " No. 3 C E.S.	1	2	12	38	27	18·68	4, 5, 3, 2, 1
Chingoor No 10 ...	4	10	15	39	18	9·0	4, 5, 3, 2, 1
North Bank No. 8 ...	32	22	15	17	9	4·34	1, 2, 4, 3, 5
" No. 9 ...	3	41	16	19	13	5·7	2, 4, 3, 5, 1

Chatla Bheel.

Silcoorie, Borokai and Dhurum Khall gardens may first be considered. Many analyses of Silcoorie are available, showing typical *teela* soils and flats. In two cases the flat soils might be mistaken for *teelas, i.e.*, Titumia and Baja flats, although in both cases the clay is somewhat higher than is usually found in *teela* soils. Both Dhurum Khall samples are of *bheels.*

Soil mark.	Coarse sand.	Fine sand	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Silcoorie No. 4 flat	2	11	20	25	34	6·44	5, 4, 3, 2, 1
" Kanki flat ...	11	36	20	15	13	3·98	2, 3, 4, 5, 1
" Ghar *teela* ...	10	43	16	11	16	4·14	2, 5, 3, 4, 1
" Jungli flat ...	5	18	31	21	19	4·48	3, 4, 5, 2, 1
" " *teela* ...	46	20	10	7	13	3·66	1, 2, 5, 3, 4
" Titumia flat	21	31	13	12	18	4·06	2, 1, 5, 3, 4
" Derby Clearance ..	53	19	8	3	4	1·92	1, 2, 3, 5, 4
" Hira *teela* ...	20	22	19	13	20	3·31	2, 1, 5, 3, 4
" South flat ...	6	35	24	18	13	3·07	2, 3, 4, 5, 1
" Baja flat ...	27	32	15	8	14	3·65	2, 1, 3, 5, 4
" No. 8 flat ...	13	51	19	7	8	2·80	2, 3, 1, 5, 4
" No. 12 flat ...	9	24	22	21	19	3·63	2, 3, 4, 5, 1
" Bunglow *teela*	33	28	13	6	16	3·74	1, 2, 5, 3, 4
Borokai ...	30	33	7	10	12	4·53	2, 1, 5, 4, 3
Dhurma Khall Kalacherra flat ...	1	16	17	36	8	16·73	4, 3, 2, 5, 1

Derby and Poloi are on either side of a low spur running from the Lushai Hills. The Derby soils are mostly *bheels*.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Derby—Poloi *kunchi*	34	31	10	12	8	4·48	1, 2, 4, 3, 5
" No. 2 ...	27	11	8	17	22	14·23	1, 5, 4, 2, 3
" No. 4 ...	7	15	19	24	25	7·36	5, 4, 3, 2, 1
" No. 9 T. P. ...	23	8	9	11	13	35·12	1, 5, 4, 3, 2
" No. 5 P. B. ...	17	12	13	9	12	36·18	1, 3, 2, 5, 4
" No. 5 P. B. ...	14	20	18	17	21	9·01	5, 2, 3, 4, 1
" No. 3 B. ...	17	3	7	8	41	22·61	5, 1, 4, 3, 2

At Poloi the soils are various types of flats, some of the samples coming from good and some from poor areas. The latter are usually lacking in organic matter. The analyses shown are typical of the great number available.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Poloi, good ..	1	14	15	33	30	8·66	4, 5, 3, 2, 1
" bad ...	5	47	14	15	13	3·95	2, 4, 3, 5, 1
" Line flat, bad ...	6	33	27	25	5	4·13	2, 3, 4, 1, 5
" " " good ...	4	22	19	30	18	7·42	4, 2, 3, 5, 1
" Banakhall S. *kunchi* ...	10	6	28	22	24	10·02	3, 5, 4, 1, 2
" Banakhall N. *kunchi* ...	27	6	19	14	13	19·43	1, 3, 4, 5, 2
" Tewari flat ...	8	24	27	13	21	6·57	3, 2, 5, 4, 1
" Dooba flat ...	6	13	26	21	22	9·60	3, 5, 4, 2, 1
" Dukhi flat No. 2	5	2	18	30	33	9·63	5, 4, 3, 1, 2
" Poloi flat No. 4	11	16	15	24	23	11·27	4, 5, 2, 3, 1

From Rukni, which stands well away from the hills, the analyses denote heavy flats and light *teelas* although in the latter the order —5, 4 for the clay and fine silt fractions is not observed.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Rukni Boudang flat ...	3	5	6	35	31	15·12	4, 5, 3, 2, 1
„ Pooni ...	48	23	7	11	7	3·61	1, 2, 4, 5, 3

Typical samples from Monierkhal are given below. Davenport *teela* is an exceptionally heavy type for a *teela*.

Soil mark.	Coarse sand	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Monierkhal	3	13	10	31	23	17·88	4, 5, 2, 3, 1
„	41	31	5	4	14	3·84	1, 2, 5, 3, 4
„	1	3	23	34	30	7·20	4, 5, 3, 2, 1
„ No. 6 *teela* ...	45	27	5	8	11	2·71	1, 2, 5, 4, 3
„ Davenport *teela* ...	25	28	8	15	18	4·87	2, 1, 5, 4, 3

The next gardens to be considered consist in those to the west of the district and the analyses include Kuttal, Ruttonpore, Rosekandy, Boro Jalinga and Noarbund. On all these gardens the usual soils representative of *teelas* and *thals* or flats are seen.

Soil mark.	Coarse sand.	Fine sand.	Silt	Fine silt.	Clay.	Loss on ign.	Soil type.
Kattal Merrowah No. 6 *teela*	40	23	10	13	8	4·09	1, 2, 4, 3, 5
„ Lag No. 3 *thal* ...	21	28	17	18	10	4·32	2, 1, 4, 3, 5
„ „ No. 2 *teela* ...	42	27	10	10	9	3·00	1, 2, 3, 4, 5
„ Bhoj *teela* No. 2 ...	11	39	15	14	15	4·17	2, 3, 5, 4, 1
„ B. P. *teela* ...	16	25	17	18	19	5·22	2, 5, 4, 3, 1
„ Singlo flat ...	7	22	29	23	15	4·53	3, 4, 2, 5, 1
„ B. P. No. 2 *thal* ...	39	30	11	10	6	2·53	1, 2, 3, 4, 5
„ No. 5 *teela* ...	39	28	9	12	8	3·30	1, 2, 4, 3, 5
„ A. P. No. 2 *thal* ...	51	32	5	6	2	1·55	1, 2, 4, 3, 5
„ „ No 7 *teela* ...	43	26	8	13	5	4·00	1, 2, 4, 3, 5
„ No. 1 *thal* M. ...	4	14	23	30	21	6·70	4, 3, 5, 2, 1
„ No. 1 *thal* Haltia ...	33	27	13	16	7	2·77	1, 2, 4, 3, 5
„ No. 1 *teela* Haltia ...	37	29	6	13	10	2·73	1, 2, 4, 5, 3
„ Sabitila, Haltia ...	48	24	9	10	5	2·47	1, 2, 4, 3, 5

The Ruttonpore samples are mostly of flats, all on the heavy side.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Ruttonpore No. 2 ...	3	15	17	27	28	7·09	5, 4, 3, 2, 1
" No. 4 Chundowa	1	4	27	33	28	6·59	4, 5, 3, 2, 1
" No. 6 Noonapani	3	24	24	21	21	6·32	3, 2, 4, 5, 1
" No. 7 Chundooadon ...	11	25	17	29	10	6 58	4, 2, 3, 1, 5

The following analyses are from the three divisions of Rosekandi.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Rosekandi No. 3 flat ...	2	33	21	22	15	5·56	2, 4, 3, 5, 1
" No. 7 " ...	41	38	6	8	4	2·24	1, 2, 4, 3, 5
" Shapore No. 5 flat	2	6	16	37	31	7·56	4, 5, 3, 2, 1
" Mains No. 9 flat	19	36	11	18	11	10 80	2, 1, 4, 3, 5
" Mains No 34 *teela*	59	18	5	8	7	2·74	1, 2, 4, 5, 3

Rosekandi no. 7 flat is extremely light for a flat, suggesting that the slope has been sufficient for the removal, by washing, of the coarse as well as the fine particles from the *teela*.

The two Boro Jalinga samples are apparently from a *teela* and a flat.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt	Clay.	Loss on ign.	Soil type.
Boro Jalinga A. ...	11	53	5	16	9	3·63	2, 4, 1, 5, 3
" B ...	15	23	18	19	18	4·97	2, 4, 5, 3, 1
Noarbund bheel No. 1 ...	35	6	11	7	4	36·01	1, 3, 4, 2, 5
" " No. 2 ...	22	20	21	10	6	18·12	1, 3, 2, 4, 5

Hailakandi.

The gardens in this district may be conveniently considered in the order as they occur down the eastern side of the valley and up the western side.

At Burnie Braes the following types occur.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Burnie Braes, Mohanpore Ext. B. ...	37	24	17	7	10	4·35	1, 2, 3, 5, 4
" New Ext. flat ...	29	32	12	13	8	5·84	2, 1, 4, 3, 5
" Zingari flat ...	47	11	10	11	10	10·49	1, 4, 2, 5, 3
" Godown flat ...	2	2	16	44	25	10·81	4, 5, 3, 2, 1
" No. 4 flat ...	31	45	7	8	5	3·82	2, 1, 4, 3, 5
" No. 1 flat ...	16	14	18	24	14	13·39	4, 3, 1, 5, 2
" Manipur ...	43	35	6	9	4	3·67	1, 2, 4, 3, 5
" Natun flat ...	12	10	18	27	20	3·14	4, 5, 3, 1, 2

Bundookmara and Kalacherra are adjoining gardens and their analyses are shown below together.

Soil mark.	Coarse sand.	Fine sand.	Silt	Fine silt.	Clay.	Loss on ign	Soil type.
Bundookmara, no blight ...	12	45	12	17	8	5·24	2, 4, 3, 1, 5
Kalacherra, blight ...	15	37	14	16	9	5·02	2, 4, 1, 3, 5
" Go-bil ...	16	7	11	24	28	11·23	5, 4, 1, 3, 2
" 10-acre flat ...	26	14	11	19	19	10·56	1, 5, 4, 2, 3
" Bendi *thal* ...	40	28	7	9	11	4·03	1, 2, 5, 4, 3

At Jaffirband the soils are various types of flats. The first and last samples are *bheels*.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine Silt	Clay	Loss on ign.	Soil type.
Jaffirband No 5 blk. 4 ..	1	5	10	36	29	17·93	4, 5, 3, 2, 1
" "A" ...	11	38	13	17	13	7·65	2, 4, 5, 3, 1
" "B" ...	47	16	7	12	13	4·09	1, 2, 5, 4, 3
" No 5 flat ...	11	24	14	27	16	5·55	4, 2, 5, 3, 1
" Kooki *thal* ...	16	34	15	15	15	4·22	2, 1, 4, 3, 5
" Sect. 5 ...	6	9	17	26	27	14·71	5, 4, 3, 2, 1

From Bagh-o'-Bahar there are four samples three of fairly stiff flats, kept friable by the *bheel* nature of the soil, and one of a *teela* of the type common in Sylhet.

Soil mark.	Coarse sand	Fine sand	Silt	Fine silt	Clay.	Loss on ign.	Soil type.
Bagh-o'-bahar No. 5 flat ...	17	18	16	18	19	11·09	5, 4, 2, 1, 3
" No. 12 flat	19	6	16	21	12	22·29	4, 1, 3, 5, 2
" Ebrahim flat	9	16	16	17	22	17·56	5, 4, 3, 2, 1
" No. 13 *teela*	57	15	8	6	9	4·20	1, 2, 5, 3, 4

From Lallamukh a great number of analyses are available showing the garden to consist largely of sandy flats. The flats which are inclined to be heavy are kept open and tractable by high organic matter percentages. Representative samples are shown.

Soil Mark.	Coarse sand.	Fine sand.	Silt.	Fine Silt.	Clay.	Loss on ign.	Soil type.
Lallamukh 88 flat ...	40	34	10	8	3	3 77	1, 2, 3, 4, 5
" 90 flat ...	4	39	14	17	19	6 45	2, 5, 4, 3, 1
" Sun No. 2 ...	8	15	15	22	29	9·75	5, 4, 2, 3, 1
" Kuki flat ..	18	34	17	13	11	6· 3	2, 1, 3, 4, 5
" N. Bichala F. ...	50	18	12	9	7	3·77	1, 2, 3, 4, 5
" No. 2 flat ...	23	16	15	18	20	6·56	1, 5, 4, 2, 3
" No. 4 ...	36	28	3	20	6	5·92	1, 2, 4, 5, 3

From Lallacherra the following are typical.

Soil mark.	Coarse sand	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Lallacherra No. 1 flat	16	9	25	16	15	15 65	3, 1, 4, 5, 2
" No. 2 flat	37	23	16	5	12	4·56	1, 2, 3, 5, 4
" Harinchra No. 1	18	26	14	20	12	8 95	2, 4, 1, 3, 5
" Manoomia	14	37	16	15	12	5·08	2, 3, 4, 1, 5
" *tila* ...	56	19	6	7	9	4·13	1, 2, 5, 4, 3

From Roopacherra—

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Roopacherra, Badlapar flat ...	7	26	14	30	16	6·53	4, 2, 5, 3, 1
" Badlapar *teela*	48	23	4	13	7	3·83	1, 2, 4, 5, 3
" Mona flat	2	6	18	36	27	9·40	4, 5, 3, 2, 1

The next four gardens, Dholai, Kukicherra, Manipur and Sultanicherra are situated in the narrow part of the Dhaleswari Valley. At Dholai the samples are all of heavy clay flats. At Kukicherra both stiff and light soils occur, although they appear

to be from flats. The heavy soils from the two gardens are very similar.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Dholai	1	7	20	·39	26	4 54	4, 5, 3, 2, 1
"	1	3	12	46	29	6 43	4, 5, 3, 2, 1
"	1	3	10	39	31	12·69	4, 5, 3, 2, 1
Kukicherra ...	4	8	19	32	26	10 50	4 5, 3, 2, 1
" ...	9	2	17	28	34	9·76	5, 4, 3, 2, 1
" ...	2	8	11	25	42	10·74	5, 4, 3, 2, 1
" ...	2	24	25	22	19	4·90	3, 2, 4, 5, 1
" ..	28	26	11	16	11	5·54	1, 2, 4. 3, 5
" ...	20	34	12	13	14	5·74	2, 1, 5, 4, 3

The Manipur samples are of great interest for they were taken from the best sections, which carry some of the heaviest yielding tea in the world. The soils yielding best are rich clay flats.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Manipur	*nil.*	5	17	44	25	8·29	4, 5, 3, 2, 1
"	25	30	13	18	9	4·35	2, 1, 4. 3, 5
"	1	6	19	41	17	15·00	4, 3, 5, 2, 1
"	*nil.*	6	15	43	27	8·02	4, 5, 3, 2, 1

The Sultanicherra samples are shown below. The first two are of a silt type, uncommon in Cachar.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Sultanicherra ...	4	15	42	19	14	6 43	3, 4, 2, 5, 1
" ...	5	22	22	28	16	5·76	4, 3, 2, 5, 1
" ...	5	4	24	40	19	6·42	4, 3, 5, 1, 2
" ...	20	23	26	15	11	3 67	3, 2, 1, 4, 5

Proceeding now up to the western side of the Hailakandi Valley, analyses are available from Appin, Koyah, Singalla, Aenakhal, New Kunchunpore, Serispore and Chandypore.

From Appin the analyses are of an old *bheel*, showing a loss on ignition of only 3.61 per cent., of flats and a *teela*.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Appin No. 1 old *bheel*	45	31	5	9	4	3·61	1, 2, 4, 3, 5
„ No. 2 flat ...	5	6	30	29	37	7·86	5, 3, 4, 2, 1
„ No 3 flat ...	3	16	19	30	10	6·76	4, 3, 2, 5, 1
„ No 7 flat ...	14	8	10	28	20	13·20	4, 5, 1, 3, 2
„ No. 13 flat	10	56	13	9	5	3·67	2, 3, 1, 4, 5
„ New *teela* ...	38	22	6	9	14	5·90	1, 2, 5, 4, 3

From Koyah only two samples are available both from flats. The Singalla analyses include both *teelas* and flats.

Soil mark.	Coarse sand.	Fine sand.	Silt	Fine silt.	Clay.	Loss on ign.	Soil type.
Koyah No. 1 flat ...	26	18	11	16	13	13·94	1, 2, 4, 5, 3
„ Manipur flat ...	26	14	12	16	16	15·24	1, 4, 5, 2, 3
Singalla, Chota harina *teela* ..	11	14	21	18	29	6·65	5, 3, 4, 2, 1
„ No. 2 *teela*...	4	15	22	27	24	5·89	4, 5, 3, 2, 1
„ Lushai *teela*	58	17	8	5	7	3·04	1, 2, 3, 5, 4
„ Manik flat ...	3	5	28	33	23	5·42	4, 3, 5, 2, 1
„ Lakri flat ...	2	26	26	21	19	5·48	3, 2, 4, 5, 1
„ Rupa flat ...	2	10	30	27	23	7·12	3, 4, 5, 2, 1
„ Lall flat ...	1	3	23	34	30	7·87	4, 5, 3, 2, 1
„ Bara Harina	5	13	22	25	26	8·55	5, 4, 3, 2, 1
„ Kachari flat	4	41	23	15	12	4·76	2, 3, 4, 5, 1

The stiff *teela* soils at Singalla are of interest, resembling as they do, the plateau soils north of the Surma.

From Aenakhal a great number of analyses are available. Typical soils are shown below.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Aenakhal, Golf *teela* ..	47	23	12	5	10	4·02	1, 2, 3, 5, 4
„ Jaynugger *teela* ...	42	22	14	6	12	3·88	1, 2, 3, 5, 4
„ Moorti *teela*	63	15	7	5	7	2·92	1, 2, 3, 5, 4
„ No. 2 *bheel*...	26	6	14	16	20	16·64	1, 5, 4, 3, 2
„ *Seedam busti*	5	27	37	13	12	4·11	3, 2, 4, 5, 1
Monacherra bungalow *teela* ...	35	36	10	4	12	2·64	2, 1, 5, 3, 4
„ Labu *teela*	9	16	25	17	25	6·94	3, 5, 4, 2, 1

The last analysis suggests a plateau soil rather than a *teela*.

The New Kunchunpore samples appear to be of flats. Those from Serispore are interesting in that some of the *teela* soils resemble the plateau soils of the Happy Valley. All the Chandypore samples are of flats.

Soil mark.	Coarse sand.	Fine sand.	Silt.	Fine silt.	Clay.	Loss on ign.	Soil type.
Kunchunpore No. 1 ...	1	3	11	33	42	8·01	5, 4, 3, 2, 1
,, No. 2 ...	2	10	30	31	20	5·45	4, 3, 5, 2, 1
,, No. 3 ...	1	9	18	35	29	6·40	4, 5, 3, 2, 1
,, No. 4 ...	5	8	14	35	30	6·60	4, 5, 3, 2, 1
Serispore Chotabar *teela*	12	14	19	11	33	10·65	5, 3, 2, 1, 4
,, Koyalhall ,,	18	34	17	11	13	5·54	2, 1, 3, 5, 4
,, No. 1 *teela*...	1	10	19	39	24	6·38	4, 5, 3, 2, 1
,, No. 2 ,, ...	35	30	11	12	8	3·87	1, 2, 4, 3, 5
,, No. 3 ,, ...	2	17	16	26	28	8·43	5, 4, 2, 3, 1
,, No. 4 ,, ..	32	21	7	13	16	6·14	1, 2, 5, 4, 3
Chandypore No. 7 flat	5	43	23	12	11	4·60	2, 3, 4, 5, 1
,, No. 8 ,,	7	36	25	16	11	5·11	2, 3, 4, 5, 1
,, No. 3 ,,	5	16	29	26	16	5·68	3, 4, 5, 2, 1

SOIL WASH.

BY

P. H. CARPENTER.

The prevention of soil loss by erosion is one of the most difficult problems confronting those who practise agriculture on sloping land. To the tea industry the problem is of great importance, and in such districts as Darjeeling and South India the prevention of soil wash may become the chief problem of the estate. The prevention of soil erosion must, however, receive attention in almost all the tea districts, for, with the exception of the Brahmaputra Valley, nearly all the other areas consist largely of sloping land. Even in the Brahmaputra Valley there are many slopes such as *hullah* sides, etc., that are obviously suffering from soil erosion.

In the case of annual crops the loss of soil by erosion might not seem to be of so great importance, were it not for the fact that it is the top layer of the soil that is lost, the only part of the soil well fitted for plant growth. If the surface layer of the soil is lost then the soil becomes, to a great extent, merely a collection of inert mineral particles. In the case of perennial crops, like tea, not only is the loss of the fertile top soil of as much importance as in the case of annual crops, but the exposure of roots by soil erosion is an additional source of loss of cropping capacity of the bushes.

The factors of most importance influencing the loss of soil from slopes by erosion are—

(*i*) Rainfall,

(*ii*) the type of soil,

(*iii*) the slope of the land.

Whilst the total annual rainfall must, to some extent, determine whether any erosion is likely to occur, yet, of more importance is the distribution of the rainfall. If the rain is evenly distributed throughout the year, with no periods of excessive precipitation, then a high annual rainfall may cause less

erosion than a much lower rainfall unevenly distributed. Consider the rainfall in Darjeeling and Buitenzorg, Java.

		India Darjeeling. ins.	Java Buitenzorg. ins.
January	...	0.76	17.6
February	...	1.08	15.9
March	...	2.01	16.6
April	...	4.08	16.2
May	...	7.83	14.9
June	...	24.19	11.1
July	...	13.74	10.2
August	...	25.98	8.2
September	...	18.34	13.5
October	...	5.35	16.7
November	...	0.24	15.6
December	...	0.20	14.6
Total	...	121.80	171.7

Buitenzorg with a higher rainfall than Darjeeling by 50 inches per annum is less likely to suffer loss of soil by erosion than Darjeeling, where the rainfall is concentrated so that 100 inches are registered in about 120 days.

The loss of soil by erosion is caused by rain that cannot soak into the soil, but is forced to run off over the surface. Consequently the nature of the soil plays a large part in determining the amount of erosion that will take place from a definite rainfall.

A coarse-grained, sandy soil into which water can easily and quickly penetrate, will be less subject to erosion than a fine grained soil through which water can only move slowly, forcing a much greater percentage of the rainfall to run off the surface. In addition, owing to the smallness and lightness of the soil particles in a clay soil, their removal will be easier than in the case of a coarse grained soil.

The depth of the easily permeable layer of the soil is also of importance, for the greater this depth the greater will be the amount of water that can be absorbed before it becomes saturated, and consequently the longer will be delayed the time when run off of water must take place. In the tea districts, however, during the Monsoon period the soil remains so near the saturation point that run off very quickly occurs no matter what the type of soil may be, and the main preventive against loss then becomes the inertia of the soil particles, or the presence of mechanical obstructions.

The slope of the land must be considered as the greatest factor governing the loss of soil by wash. On a steep slope, the water as it runs off a smooth surface of soil (and under the battering effect of direct rainfall a soil surface quickly becomes smooth) attains such a velocity that it is capable of carrying along with it soil particles. The greater the velocity of the water the larger the soil particles that can be moved.

The following table gives the velocity of water in inches per second required to move particles of varying sizes.

Rate of water flow.							Size of particles moved.
3	ins. per sec.	or	0.170	miles per hour		...	Clay.
6	,,	,,	0.340	,,	,, ,,	...	Fine sand.
8	,,	,,	0.455	,,	,, ,,	...	Sand as coarse as linseed.
12	,,	,,	0.682	,,	,, ,,	...	Fine gravel.
24	,,	,,	1.364	,,	,, ,,	...	Pebbles 1 inch in diameter.
36	,,	,,	2.045	,,	,, ,,	...	Small stones.

It is difficult to obtain any accurate figures regarding the rate at which water runs off a soil slope, but some approximate idea of this can probably be obtained by the use of the formula relating to the flow of water in drains, *viz.*

$$V = C \sqrt{R \times S}$$

where V = the velocity of the water in the drain in feet per second.

R = Cross sectional area of drain in square feet divided by the wetted perimeter of drain in lineal feet.

S = The slope of the land.

C = A coefficient obtained from Bazin's formula for water flowing in earthen channels.

$$= \frac{1}{\sqrt{\frac{\cdot 00008534(R + 4\cdot 1)}{R}}}$$

If the width of the water flow is very much greater than the depth of the water, *e.g.*, if we consider not a drain, but water flowing freely over the surface, then, the maximum velocity of the water is directly proportional to the depth of the water and the square root of the slope.

The following table gives the maximum velocity, in feet per second, for varying depths of water and of slope.

Velocity of water in feet per second.

Slope.	Depth of water.			
	1 inch.	¾ inch.	½ inch.	¼ inch.
1 in 100	0·44	0·33	0·22	0·11
1 ,, 80	0·50	0·37	0·25	0·12
1 ,, 60	0·56	0·43	0·28	0·14
1 ,, 40	0·70	0·52	0·35	0·17
1 ,, 20	1·00	0·74	0·50	0·25
1 ,, 10	1·4	1·05	0·70	0·35
1 ,, 6	1·80	1·35	0·90	0·45
1 ,, 5	1·97	1·48	0·98	0·49
1 ,, 4	2·20	1·66	1·10	0·55
1 ,, 3	2·55	1·91	1·27	0·63
1 ,, 2	3·12	2·34	1·56	0·78

Water flowing at a depth of one inch over a slope of 1 in 100 will attain a maximum velocity of .44 feet or 5¼ inches per second. This will be a sufficient velocity to remove fine clay, but not sufficient to remove fine sand or any larger sized soil particles.

If the water were flowing with a depth of only half an inch then no particles of soil would be moved. Reference to the above table shows that the slope would have to be increased from 1 in 100 to 1 in 80 in order to move clay particles with water flowing at a depth of half an inch.

If the water had a depth of only ¼ inch then the fine clay particles would not be moved until the slope became 1 in 20.

For fine sand to be moved with a depth of water of one inch the slope would need to be 1 in 80. With half an inch of water the slope would have to be increased to 1 in 20.

A heavy fall of rain may produce a depth of water that may easily attain a velocity sufficient to carry away sand particles, and, if the slope is long, the accumulated water from the upper parts of the slope may reach a depth on the lower part sufficient to cause most serious erosion.

The amount of water that will percolate through the soil varies with the class of soil. For instance, fine sand (passing through 100-mesh sieve) will allow 40 inches of water to pass in 24 hours through a column 14 inches in depth, with a head of water maintained at two inches.

On the other hand, a clay loam, under similar conditions, will allow only 1.6 inches of water to pass through. This seems to indicate that a sandy soil, containing no fine particles, would allow water to pass through at a rate sufficient to deal with a rainfall of one inch per hour, if not extended over several hours.

When the spaces between the soil particles become filled with water, the soil is then saturated and unless the rate of percolation is rapid, practically all the rain falling after that condition is reached must run off. It is therefore of interest to know the amount of water that will run off an area from a definite rainfall.

The following table shows the cubic feet of water collecting on one acre of land at various hourly rates of rainfall.

Rainfall inches per hour.

Rainfall per hour.	$\frac{1}{10}$ inch.	$\frac{1}{8}$ inch.	$\frac{1}{4}$ inch	$\frac{1}{2}$ inch.	1 inch.	2 inches.
Cubic feet water falling on an acre per hour ...	363	454	901	1,815	3,630	7 620

For a rainfall of one inch per hour the drain discharge for one acre, assuming that all the water ran off, would need a capacity of 3,630 cubic feet per hour, equal to 22,690 gallons. Taking a safe velocity of water in an ordinary earth drain to be 2.5 ft. per second, then a drain with a 6-inch bottom sloping at 1 in 16 will fill to a depth of 9½ inches in carrying away the volume of water under consideration *viz.*, 22,960 gallons.

Whilst the figures above are but approximations, yet they are of considerable interest in indicating how very necessary it is to take precautions against soil wash on even very slight slopes. They also indicate how very necessary it is to control the run off over a slope before it has attained more than a slight depth, and the greater the slope the greater the necessity for control. Detailed attention must also be paid to the discharge capacity of the drains and their angle of slope.

The difficulties to be overcome to prevent erosion on tea gardens are very serious and unfortunately there is little experimental data dealing with the subject. Considerations, therefore, of the means that may be adopted to minimise the trouble are largely based on theoretical data and general experience.

The prime factor of the problem appears to be how to reduce the velocity of the flow of water over a slope to such an extent that erosion will not take place. This can be done in several ways. The first and probably the most efficient method is by terracing, arranging that the slope of the terrace in any direction is not great enough to allow of soil movement. The run

off water from each terrace must be taken away under control in its own drainage channels, and not allowed to pass from one terrace to the next lower one. On the more gentle slopes, terraces can be formed by building contour *bunds*, but on steep slopes the terraces must be cut out.

A slope of 1 in 5 would require a *bund* 9 inches high every 5 feet in order to form a terrace having a slope of 1 in 20 on which water ¼ inch deep would attain a velocity that it could just move clay and no other particles. Such *bunding* would be impracticable so that, for this slope, cut terraces are required.

A slope of 1 in 10 would require a *bund* 6 inches high every 10 feet in order to form a terrace with slope of 1 in 20.

It is only necessary to go into forest land on hillsides to realise that some conditions are present that very materially reduce soil erosion. Perhaps three of these factors may with advantage be mentioned.

(1) The first is the overhead cover provided by the growing trees. This prevents, to a very great extent, the battering effect of the rain falling directly on to the soil and reduces the velocity of the rain drops before they reach the ground.

(2) The second is the random distribution of jungle plants. The absence of any straight line effect up and down the hill does much to prevent the formation of water gullies.

Unfortunately on many tea gardens the bushes are planted in straight lines up and down the slope, a form of planting tending seriously to increase erosion. In such areas it is often noted that water channels form in the lines between the bushes, and if very careful precautions are not taken to prevent soil loss, in a very few years the bushes are gradually left on pinnacles or very narrow individual terraces.

The type of planting providing the greatest amount of immunity from wash is regular contour planting. Because this method of planting is not quite so simple as straight up and

down planting it was not generally adopted in the earlier days. With regard to the supposed greater working inconvenience on contoured areas, it is true that it does make the garden operations of plucking and pruning less easy, but on the other hand it does reduce the tendency to cultivate up and down the hill, another source of soil loss to the upper slopes. Contour planting does not interfere with cultivation but rather aids it, in that it induces it to be done in a better manner.

(3) Another factor reducing soil wash in the jungle is the accumulation of organic matter in the form of dead branches, twigs and leaves. These provide a mulch over the soil and very largely act as a protective layer, which no doubt itself suffers loss, but is renewed year by year.

It would seem possible to utilise this method in tea gardens by leaving the annual leaf fall from the bushes and also the prunings and jungle growth that have been sickled, on the surface, instead of turning it under the soil. Undoubtedly such a procedure would very materially reduce soil loss and such methods have at times been employed, but the continuance of such a practice on any one particular area requires caution, for the collection of rotting organic matter tends to accumulate against the stems of the tea bushes and disease can readily spread from the rotting matter to the tea bush itself. This has happened many times in tea, and outbreaks of disease, *e.g.*, *Rosellinia arcuata*, have occurred which may easily assume serious proportions. Another real danger is that the encouragement of such a mulch on the surface of the soil encourages the propagation of insect pests.

Although a mulch of rotting vegetable matter cannot be safely employed to stop soil wash, a growing crop may be used with the same object. Weeds and small plants growing as a cover on the soil do greatly help to prevent wash, partly because the roots tend to bind the soil but mainly by reason of the check upon the rate of flow of water over the soil surface. In this manner it is possible to prevent the water from reaching a velocity that it would attain in flowing over a clean land slope.

Unfortunately the growing of jungle on a tea area reduces the crop but it is noticeable that certain classes of jungle do this far less than others. Shallow rooting plants have a less harmful effect than have some of the deeper rooting grasses.

If, therefore, the use of a cover crop is to be employed for preventing soil wash, a system of selective weeding must be adopted. So far but very little has been done in North-East India in this direction although other tea districts have given the matter rather more attention. Selective weeding, however, has its difficulties and perhaps a simpler way of dealing with the matter is to grow some shallow rooting crop. This has been tried and a number of plants appears to have given successful results, *e.g.*, *Indigofera endecaphylla*, *Vigna oligosperma*, *Desmodium triflorum*, *Crotalaria incana*, Mixed *crotalaria*, *Ipomaea*.

The following figures afford comparative data. They are taken from the records of the Peradeniya Experimental Station, Ceylon, showing the loss of soil by erosion on unprotected soil and also on soils on which various plants are being grown.

	Loss by erosion in lbs.
Soil untreated ...	... 814
Crotalaria incana ...	... 309
Mixed *crotalaria* ...	... 176
Ipomaea ...	... 133
Desmodium triflorum	... 30

Ashplant in his experiments on an area growing rubber on a slope of 1 in 5 gives the following comparative data :—

	Loss of soil by wash. tons.	cwts.
Plot 3, leguminous cover crop ...	0	14.4
,, 4, hand weeded	5	17.3
,, 5, weeded by *mamooty* (light cultivation)	7	17.0

Another pair of plots shows the effect of allowing weeds to grow.

	Loss of soil by wash.	
	tons.	cwts.
Plot I, no deep cultivation. Light cultivation by *mamooty* (hoe) ...	22	4.6
Plot II, no deep cultivation. Circles around trees only clean weeded	0	1.6

The reduction of the velocity of water over a slope can also be accomplished in some measure by growing certain plants in the form of hedges along the contour. Thus—

	Loss by erosion in lbs.
Crotalaria in lines across slopes ...	50
Untreated soil	814

The battering of the rain on the soil surface of a slope quickly tends to produce a smooth surface over which the water can attain maximum velocity. If the soil surface can be kept in a rough uneven state then the velocity of the water will be greatly retarded.

	Soil lost by wash.	
Treatment.	tons.	cwts.
Plot 1, no deep cultivation ...	13	13
,, 5, deep cultivation	7	17

Both plots were weeded by *mamooties* (light cultivation).

Plot 4, hand weeded	5	17
,, 5, weeded by *mamooty* (light cultivation)	7	17

The following data obtained by Ashplant from an experiment on a rubber planted area in South India are of value.

	tons.	cwts.
Plot IV, hand weeded, deeply dug before experiment	5	17.3
Plot V, hoed *mamooty*, but deeply cultivated shortly before experiment	7	17.0

		tons.	cwts.
Plot I,	hoed *mamooty* but no cultivation by digging for eight months previous to experiment ...	22	4.6
Plot VI,	Contour pits and bunds with clean weeding	1	17.6

The slope of the land on which the above experiments are being conducted is 1 in 5. The area is under rubber trees.

Cultivation, providing a loose layer of soil, allows the rainfall to soak quickly into the soil and thus prevents water remaining on the surface. So long as the soil can absorb the rain that is falling for so long will there be no loss by wash. It is not until the soil can no longer absorb the rainfall that run-off over the surface takes place. This seems clearly to indicate that the deeper a soil is loosened the less will be the likelihood of run off. That is to say that deep cultivation will prevent loss by wash, more effectively than shallow cultivation. This is borne out by the data given above.

It is however necessary to remember that a soil layer saturated with water resting on a more compact layer has a tendency to slip as a whole, and consequently on well cultivated areas the provision of contour drains that will carry the water away from the area are necessary. Contour drains must also be so devised that water does not remain in them but that it is quickly discharged so that the soil in the neighbourhood of the drain is not kept in a saturated condition.

On cultivated land the finer particles of soil may often be washed away but the coarser particles such as sand may be left behind. The layer of sand on the soil surface then acts as a mulch of coarser particles and prevents the erosion of the soil below the layer. When such a layer is formed the soil should not be dug to a depth greater than the depth of the sandy layer for every time deeper digging is done a fresh layer of soil containing finer particles is brought to the

surface and the finer particles washed away. A sandy layer of soil having a depth of perhaps 7 to 8 inches can be obtained and this prevents soil loss, but great care needs to be taken to remove the water that percolates through the sandy layer as quickly as possible so as to prevent its becoming so saturated with water as to allow a slip to take place.

When devising contour drains to remove the water it is obvious that they must not have so great a slope as to allow the water to attain such a velocity as to erode the drain, nor to carry away in suspension any of the larger sized soil particles. It is often difficult so to construct drains that fulfil all the necessary conditions. In such cases where the drain slope is unavoidably too great much can be done to reduce the velocity of the water by filling the drains with faggots of prunings or similar material.

Protection by shading with trees or by the foliage of the tea bushes themselves, also helps to reduce soil wash. The effect of shade is very clearly to be noticed on some tea areas in the hilly districts of North-East India and under areas on which the tea bushes are fully grown.

The following data obtained from Ceylon illustrate—

	Loss by erosion in lbs.
Soil unshaded	814
Dadap (*Erythrina indica*)	330
Albizzia	168

ON THE INCIDENCE OF INSECT PESTS AND FUNGUS DISEASES ON TEA AT TOCKLAI.

BY

E. A. ANDREWS.

At the end of 1917 a small area of tea at Tocklai, planted in the cold weather of 1915-16, was set aside for the purpose of making observations on the incidence of insect pests, and on the possible effect of different treatments in encouraging or discouraging attack by different pests.

The different treatments initiated were as follows:—

Manuring—	Plot	A	to receive	Nitrogen and Potash.
	,,	B	,,	Nitrogen only.
	,,	C	,,	Nitrogen & Phosphoric Acid.
	,,	D	,,	Potash only.
	,,	E	,,	Potash & Phosphoric Acid.
	,,	F	,,	Phosphoric Acid only.
	,,	G	,,	No manure.
	,,	H	,,	Nitrogen, Potash & Phosphoric Acid.
Pruning—	,,	I		to be cleaned out when pruning.
	,,	J		not to be cleaned out.
	,,	K		to be pruned badly so as to leave snags.
	,,	L		to be pruned carefully to leave no snags.
	,,	M		not to be collar pruned.
	,,	N		to be collar pruned.
	,,	O		to be pruned on one-year wood.
	,,	P		to be pruned on two-year wood.
Miscellaneous—	,,	Q		to be plucked hard.
	,,	R		to be plucked lightly.
	,,	S		to be kept clean and free from jungle.
	,,	T		to be allowed to be smothered in jungle.

Plot U to be treated at intervals with lime-sulphur.
,, V to be treated at intervals with Bordeaux mixture.
,, W to receive no such treatment.

At convenient intervals during each subsequent year, the bushes have been subjected to careful observation and the insects (and fungi) occurring on each bush recorded. In all, 49 observations have now been made, and as certain small differences in behaviour are beginning to be noticeable it has been decided to commence the issue of a series of progress reports on the behaviour of the different pests.

It is interesting, first, to note the relative frequency with which the different pests were found on the area. This is shown in the following list, the possible number of occurrences being 6,762.

Insects and Mites—	Red Spider	Occurred	5382	times.
	Tea Aphis	,,	1850	,,
	Leaf Rollers	,,	448	,,
	Nettle Grubs	,,	124	,,
	Tea Seed Bug	,,	98	,,
	Gelatine Grubs	,,	66	,,
	Termites	,,	36	,,
	Looper Caterpillar	,,	28	,,
	Sandwich ,,	,,	14	,,
	Scale Insects	,,	12	,,
	Lymantriid Caterpillars	,,	8	,,
	Red Borer	,,	4	,,
	Bark Eating Borers	,,	2	,,
	Faggot Worms	,,	2	,,
	Tea Leaf Mining Fly	,,	2	,,
	Red Slug	,,	1	,,
	Conical Psychid	,,	1	,,

Fungi—				
	Brown Blight	Occurred	6624	times
	Red rust	,,	5224	,,
	Cercospora	,,	402	,,
	Copper blight	,,	52	,,
	Stem diseases	,,	12	,,
	Grey blight	,,	6	,,
	Blister blight	,,	2	,,

The relative importance, on these plots, of the various insect pests and fungus blights, is very well shown.

It is, moreover, obvious that in the case of most of the pests and blights the number of occurrences has been so small that the accidents which affect the distribution of all pests and blights cannot be ignored, and no reliable conclusions on the effect of the different treatments on their distribution can be drawn.

In the case of red spider, tea aphis, and leaf rollers among the insects, and of brown blight, red rust, and Cercospora among the fungi, however, there is a sufficient number of observations to make a study of the records worth while. Taking the number of times a pest or disease has been recorded from the bushes in a plot, and dividing by the number of bushes in the plot, one obtains a figure for the average number of times each bush in a plot was found to be infected.

In this way the following table is obtained :—

Plot.	Treatment.	Brown blight.	Red rust.	Cercospora.	Red spider.	Tea Aphis.	Leaf Rollers.
A	Nitrogen and Potash ...	36·0	23.5	1·5	23·2	9·7	1·8
B	Nitrogen only ...	40·5	26·5	2·3	24·8	9·5	1·7
C	Nitrogen and Phosphoric Acid	38·3	25·2	1·5	25·7	10·3	1·8
D	Potash only	35·0	28·0	1·6	25·0	10·5	1·3
E	Potash and Phosphoric Acid	32·5	23·0	1·2	26·0	10·3	0·8
F	Phosphoric Acid ...	37·0	26·7	2·0	28·5	9·2	3·0
G	Nil	38·0	26·8	2·8	26·8	9·0	3·5
H	Nitrogen, Potash and Phosphoric Acid ...	33·6	30·6	1·5	24·5	11·0	2·6

Plot.	Treatment.	Brown blight.	Red rust.	Cercospora.	Red spider.	Tea Aphis.	Leaf Rollers.
I	Not cleaned out in pruning	30·5	40·2	1·3	31·5	8·0	1·3
J	Cleaned out ...	25·7	20·0	1·7	24·0	11·2	2·0
K	Snag pruned... ...	28·0	35·3	1·3	31·7	10·0	1·7
L	Clean ,, ...	25·7	18·3	1·5	29·0	10·2	1·2
M	Not collared	28·2	20·8	1·5	27·5	7·7	2·5
N	Collared	25·5	18·5	1·5	22·6	11·2	2·5
O	Pruned on 2-year wood ...	27·5	25·3	1·0	28·0	11·5	2·0
P	Pruned on 1-year wood ...	27·6	20·0	1·2	23·6	10·3	2·5
Q	Hard plucked ...	36·7	28·3	3·3	32·2	9·5	9·5
R	Lightly ,, ...	38·7	28·2	3·5	28·6	9·0	9·0
S	Free from jungle .	38·0	30·3	3·0	30·0	8·0	8·0
T	Overrun with jungle ...	35·9	24·5	2·8	20·3	4·7	4·7
U	Lime-sulphur ...	38·0	28·0	3·0	30·5	8·0	8·0
V	Bordeaux mixture ..	34·3	27·0	3·7	26·0	7·7	7·7
W	Untreated	36·6	28·8	1·5	29·2	6·3	6·3

With the help of the above table the incidence of a pest or blight can be compared with the treatment the different plots received.

The results on most of the manured plots are irregular, but it will be observed that in the case of all three fungi the plot which has consistently received potash and phosphoric acid was observed to be infected on the fewest number of occasions. In view of the number of observations this can hardly be coincidence, and moreover the observation is in line with the results obtained at Borbhetta, where it has been found that, whereas potash applied alone may have little effect, its effect becomes very marked when phosphoric acid is applied with it. With regard to insects and mites the manuring has had no influence which can be traced.

In the plots devoted to pruning treatments the results are more strongly marked. It will be observed that in the case of brown blight, red rust and red spider all processes which tend to bring about the retention of poor and old wood in the bushes for a shorter or longer period cause an increase in the prevalence of the fungus. Thus the plots carefully cleaned out and carefully pruned show less infection than those in which cleaning out is omitted and pruning done carelessly, so that the bushes are full of unproductive and non-vegetative shoots. In the plot

which was not collar-pruned there is a tendency for there to be more shoots of this kind than in the plot in which the bushes have been built up on clean straight stems from the ground, and there is a consequent increased liability to presence of the diseases. In the tea pruned only every other year, too, unproductive shoots remain on the bushes long enough to be affected. Cercospora, and tea aphis, on the other hand, appear to prefer light and air in the bushes, and sound flushing shoots, while the distribution of leaf rollers shows no relation to the treatment.

Hard plucking seems to have had no effect, so far, in increasing liability to attack by fungi, in fact the figures tend to show the opposite result. Red spider has shown up a little more on the hard-plucked bushes, while the leaf-rollers, as is only to be expected, show up more on the lightly plucked bushes.

A noticeable feature is that the plot left smothered in jungle the whole time has been distinctly less attacked by both insects and fungi than the plot, alongside, in which jungle was always kept down.

Spraying has scarcely affected the incidence of pests and blights, though the Bordeaux mixture wou'd appear to be better as a preventive than Lime-sulphur.

It should be noted that all the above remarks refer to the incidence of the various pests and blights, and not to the amount of damage done. This is not being measured in this experiment.

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1911	Available.	Available.	Available.	Available.	0 6 0
1912	do.	do.	do.	do.	0 6 0
1913	Out of Stock.	do.	do.	Out of Stock.	0 6 0
1914	do.	do.	do.	Available.	0 6 0
1915	Available.	Out of Stock.	do.	do.	0 6 0
1916	Out of Stock.	Available.	Out of Stock.	Out of Stock.	0 6 0
1917†	do.	do.	do.	Available.	0 6 0
1918	do.	Out of Stock.	Available.	Out of Stock.	0 6 0
1919	Available.	Available.	do.	Available.	0 6 0
1920	Out of Stock.	Out of Stock.	Out of Stock.	Out of Stock.	0 6 0
1921	Available.	Available.	Available.	Available.	0 8 0
1922	do.	do.	do.	do.	0 12 0
1923	do.	do.	do.	do.	0 12 0
1924	do.	do.	do.	do.	0 12 0
1925	do.	Not available.	do.	do.	0 12 0
1926	do.	Available.	do.	do.	0 12 0
1927	do.	do.	do.	do.	0 12 0
1928	do.	do.	...	...	0 12 0

†Bound volume for 1917 is available.

Copies of the above, except those which are out of stock, may be had from the Secretary, Indian Tea Association, Calcutta (Post box 280).

Corrected up to 31st July 1928.